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ORIGINAL ARTICLE

Revealed Comparative Advantage of Strawberry Production in International Trade

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Abstract

This study analyzes the export performance and competitive strength of 15 leading countries in the global strawberry trade during the period from 2009 to 2023 by using the revealed comparative advantage (RCA) index. Strawberry is a high value-added agricultural product in terms of both fresh consumption and processed goods, and its global production has increased from 6,536,529 t to 10,485,454 t over the past 15 years. According to the Food and Agriculture Organization Corporate Statistical Database, China, the United States, Mexico, Türkiye, and Spain are among the largest producers, with China and the United States particularly standing out in terms of production efficiency. Analyses based on the RCA index show that countries such as Spain, Mexico, Egypt, Morocco, and Greece possess a comparative advantage in strawberry exports, while Türkiye's RCA values remained below 1 in most years, showing advantage only in certain periods. By presenting countries' net export values, export-to-import coverage ratios, and year-over-year changes in a comparative manner, this study contributes to the literature by extending the RCA-based analysis of competitiveness in strawberry trade to a broader temporal and spatial context.

Keywords Strawberry trade · Net Export · Balassa index · RCA index

Introduction

Strawberry, the most widespread and extensively cultivated species among berry fruits, is a highly significant agricultural product worldwide. It belongs to the order Rosales, the family Rosaceae, and the genus *Fragaria* (Aybak 2005). Native to South America (Chile), strawberry is a herbaceous yet perennial fruit species. Its suitability for early-season production, strong demand in both domestic and international markets, and ongoing breeding efforts have contributed to its growing global prevalence (Ertürk et al. 2017).

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Indeed, strawberries are commercially produced in more than 70 countries, with China, the United States, Mexico, Türkiye, and Spain ranking among the top producers. Global production has increased by 142% over the past 20 years (Simpson 2018).

Strawberries are also nutritionally rich, particularly noted for their high vitamin C content. Approximately 100 mg of ascorbic acid is found in 100 g of fruit. Their rich cellulose content aids digestion, and due to their high ellagic acid concentration, they also possess cancer-preventive properties. A 100-g portion of strawberries contains 40–45 calories, significant amounts of vitamins A and B, minerals such as calcium, iron, and phosphorus, and trace amounts of bromine, silicon, iodine, and sulfur (Aybak 2005). Strawberries are consumed not only as food but also in large quantities in the form of fresh fruit, juice, pie, jam, ice cream, chocolate, and milkshake. Commercially, they are cultivated both for direct fresh consumption and for processing into frozen, canned, or juice products. However, despite their high economic value, the short postharvest shelf life of strawberries makes the application of proper preservation techniques critically important. To ensure that the fruit reaches consumers without physiological deterioration, pre-cooling, cold storage, and controlled atmosphere

preservation techniques should be employed (Qureshi et al. 2023).

Despite challenges such as climate change, logistics costs, and customs tariffs, the global strawberry industry continues to grow. Its wide range of value-added applications—from fresh produce to cosmetics and frozen foods—makes strawberries indispensable across many sectors (Globy Editorial Team 2025). In this context, strawberry production has become a strategic field not only in agriculture but also in logistics and food technologies.

According to FAOSTAT 2023 data, China ranks first in global strawberry production with a share of 40.2%, followed by the United States with 11%, Egypt with 7%, and Türkiye with 6.5% (FAOSTAT 2025). Data from Mordor Intelligence (2024) indicate that the global strawberry market reached a size of USD 14.7 billion in 2024 and is expected to grow to USD 18 billion by 2030, with a compound annual growth rate of 4.1%. In particular, the widespread adoption of protected cultivation techniques and the increasing year-round supply demand in the Asia-Pacific region are contributing to the rapid development of production infrastructure.

On the other hand, international fruit trade—particularly in high value-added products such as strawberries—is directly affected by external factors including customs tariffs, logistics costs, and climate-related risks. Deschênes and Greenstone (2007) demonstrated that agricultural production is highly sensitive to climatic variables such as temperature and precipitation, which play a decisive role in production continuity and trade volume. Nevertheless, strawberry production and consumption continue to increase globally; beyond serving as raw material, strawberries are widely used in processed and value-added forms across sectors ranging from confectionery to cosmetics. Therefore, investigating the position of strawberries in international markets and examining how global strawberry exports and competitiveness have evolved over the past 15 years (2009–2023) is of significant importance.

This study focuses on the competitive strength of strawberry exports in the international market. Theoretically, countries' competitiveness is based on Ricardo's theory of comparative advantage and the principles of international trade, which help explain how certain nations establish and sustain their presence in global markets (Casanova and Zuaznábar 2018). In this context, the revealed comparative advantage (RCA) theory developed by Balassa (1965), which is the most widely used in academic literature, has been employed to identify international competitiveness in strawberry trade. Methodologically, the RCA index provides a quantitative approach to assess the competitiveness and stability of trade flows in various contexts (Ninaquispe et al. 2025).

Various studies have employed the RCA approach to analyze the competitiveness of agricultural food products across different regions and markets. These include investigations into Türkiye's walnut trade (Ketenci and Bayramoğlu 2018), peach and nectarine trade (Bayav and Çetinbaş 2021), fresh and dried apricot trade (Süygün 2021), citrus trade (Duru et al. 2022; Gültekin et al. 2022), and oilseed trade (Kadakoğlu et al. 2023). Ghani et al. (2023) examined India's comparative advantage in banana trade. In addition, there are studies that explore comparative competitiveness in selected products and countries on a global scale, such as cherries (Ninaquispe et al. 2024), fresh grapes (Cano-Espinosa and Méndez-León 2025), table and dried grapes (Topçu and Başer 2025), and lemons (Kadakoğlu and Gül 2025).

On the other hand, there is a limited number of studies that examine the competitiveness of strawberries in the international market. Among them, Cossio and Flores (2021) analyzed the competitiveness of Mexican strawberries in the United States market from 1992 to 2017. Attia et al. (2024) investigated the position of Egyptian strawberries in the import market, using the RCA and gravity model to assess the country's competitive status in the frozen strawberry segment. Ninaquispe et al. (2025) focused on five leading countries in global strawberry exports and revealed their comparative advantage between 2019 and 2023 using the RCA method.

The reviewed literature reveals that although numerous studies have examined product-based competitiveness, research focusing on strawberries has predominantly concentrated on specific regions and covered relatively short time periods.

This study examines the competitive strength of 15 leading strawberry-exporting countries in global trade during the 2009–2023 period. It is believed that the study will make a significant contribution to the literature, both in terms of the time span covered and the number of countries analyzed. Moreover, the findings of this research may not only provide valuable insights for agricultural exporters and companies but also help countries enhance their competitive advantages and strengthen their adaptability in dynamic markets.

Materials and Methods

Materials

To highlight the position and significance of strawberries in the global market and to assess the export competitiveness of 15 leading countries, the dataset used in this study was derived from the statistics of the United Nations Food and Agriculture Organization (FAOSTAT 2025). The selection

Table 1 Production volumes and change rates of selected berry fruits, 2009–2023 (FAOSTAT 2025)

	2009 Production quantity (t)	2023 Production quantity (t)	2009–2023 Rate of change %
Strawberry	6,536,529	10,485,454	60.41
Raspberry	564,022	940,979	66.83
Currant	690,469	759,280	9.96
Blueberry	383,518	1,220,665	218.28
Gooseberry	168,385	97,505	–42.09

of the top 15 countries in global strawberry trade was based on their export values in 2023. These countries, ranked by export value, include: Spain, Mexico, the United States, the Netherlands, Belgium, Greece, Egypt, Morocco, the Republic of Korea, Italy, Japan, France, Türkiye, Canada, and Poland (FAOSTAT 2025). Using production data from the 2009–2023 period, the RCA index was calculated for each country, and comparative analyses were conducted. Additionally, countries' net export values, export-to-import coverage ratios, rates of change, and percentage variations were calculated and interpreted.

Methods

In this study, the RCA index is used to quantitatively assess the competitive strength of 15 leading strawberry-exporting countries in international markets.

The RCA is a widely used method for evaluating a country's product competitiveness in international trade and its potential to benefit from bilateral trade. This approach calculates comparative advantage by analyzing a country's export trade flows for specific products in specific markets (French 2017). The RCA is commonly applied to measure the agricultural export performance of countries and is expressed as follows. The RCA index is calculated using Eq. 1 below (Balassa 1965):

$$RCA_{ij} = \left(\frac{X_{ij}}{X_j}\right) / \left(\frac{X_{iw}}{X_w}\right) \quad (1)$$

In this equation:

RCA = Revealed comparative advantage coefficient of country *j* in product group *i*
X = Total export value of product *i* by country *j* (in USD)
X = Total export value of all products by country *j* (in USD)
X_w = Total global export value of product *i* (in USD)
X_w = Total global export value of all products (in USD)

According to the results obtained, a country is considered to have a comparative advantage when the index calculated through the RCA method exceeds 1. Conversely, a country is deemed to have a comparative disadvantage when its RCA value falls below 1. If the RCA value equals 1, it indicates neither a comparative advantage nor a relative export disadvantage. Based on Eq. 1, the RCA values of the 15 selected countries were compared using tables and figures.

Results and Discussion

To clearly understand the position of strawberries in the global market, it is essential to identify their standing among similar cultivated products. For this purpose, global berry fruit production and its development during the research period were examined, and the relevant data are presented in Table 1. Upon reviewing these figures, it becomes evident that there have been significant increases in berry fruit production worldwide. Among these, strawberries stand out as the most widely produced fruit globally by a considerable margin. During the study period, strawberry production increased by 60.41% from 2009 to 2023, reaching 10.5 million t. In the same period, raspberry production rose by 66.83%, while blueberry production showed a striking increase of 218.28%. Blueberries, in particular, have gained special importance among fresh fruits and vegetables due to their high antioxidant capacity and high concentrations of anthocyanins and other phenolic compounds, which have led to a noticeable rise in consumer demand (Prior et al. 1998). In contrast, currant production grew by only 9.96%, and gooseberry production declined from 168,385 t to 97,505 t (Table 1).

Figure 1 presents global data on strawberry cultivation area and production volume over an extended period. Analyzing the 1990–2023 timeframe reveals a strong and positive correlation between the area harvested and the quantity produced. The gradual expansion of harvested land has supported the rise in production volume, reflecting the impact of improvements in agricultural productivity and the adoption of modern cultivation techniques. Specifically, the harvested area increased from 209,624 hectares in 1990 to 434,977 hectares in 2023, while production rose from 2,462,167 t to 10,485,454 t during the same period. This remarkable growth in both production and harvested area is considered a concrete indicator of technological trans-

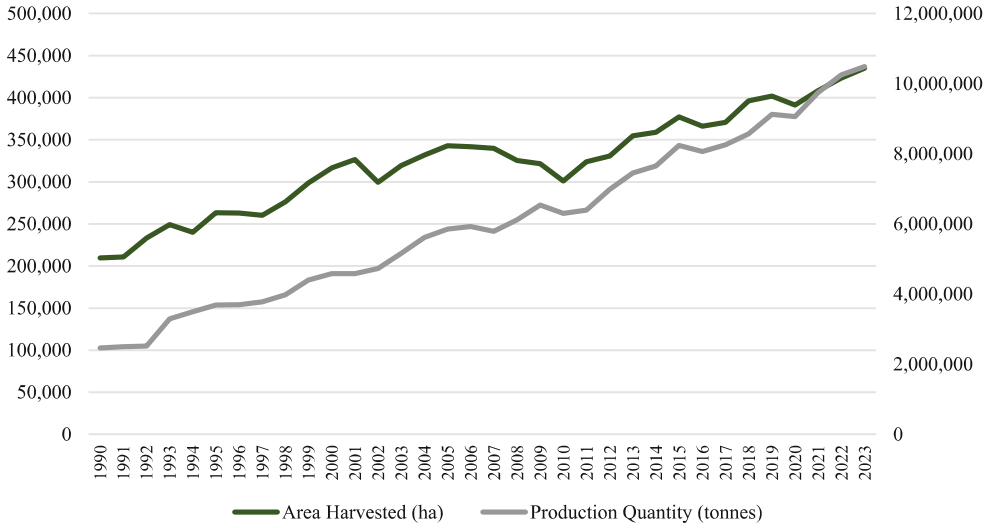

Fig. 1 Global strawberry production quantity and harvested area, 1990–2023 (FAOSTAT 2025)

formation in agriculture, the use of high-yielding varieties, and enhancements in production processes (Fig. 1).

Strawberries are a highly demanded fruit for industrial use and attract significant consumer interest. With their rising commercial value worldwide, they have become increasingly prominent in global markets. Accordingly, in addition to production volumes, it is important to examine the size of cultivation areas and productivity levels across countries. In this context, the production quantities and cultivation areas of selected leading countries have been analyzed and presented in Fig. 2.

China ranks first in global strawberry production with a share of 40.2%, and also holds the largest cultivation area with 35.9% of the total. These figures indicate that China maintains a balanced relationship between production capacity and cultivated area, achieving a high overall production volume. More notably, the United States produces 11.9% of the world's strawberries, using only 5.3% of the cultivation area. This highlights the United States' high production efficiency and effective use of advanced agricultural technologies (Fig. 2).

Similarly, Spain achieved 3.1% of global strawberry production despite having only 1.7% of the total cultivation area. These figures demonstrate that developed countries like Spain can obtain higher-than-expected yields through the use of modern agricultural systems. This supports studies suggesting that developed nations may also possess comparative advantages in agriculture (Ministry of Agriculture and Forestry 2022). Countries such as Egypt, Türkiye, Brazil, and the Republic of Korea also exhibit above-average productivity, with closely aligned ratios of production volume and cultivation area (Fig. 2).

On the other hand, in countries such as Russia and Poland, although the cultivation areas are relatively large, the production volumes remain comparatively low. This indicates low productivity in strawberry cultivation in these

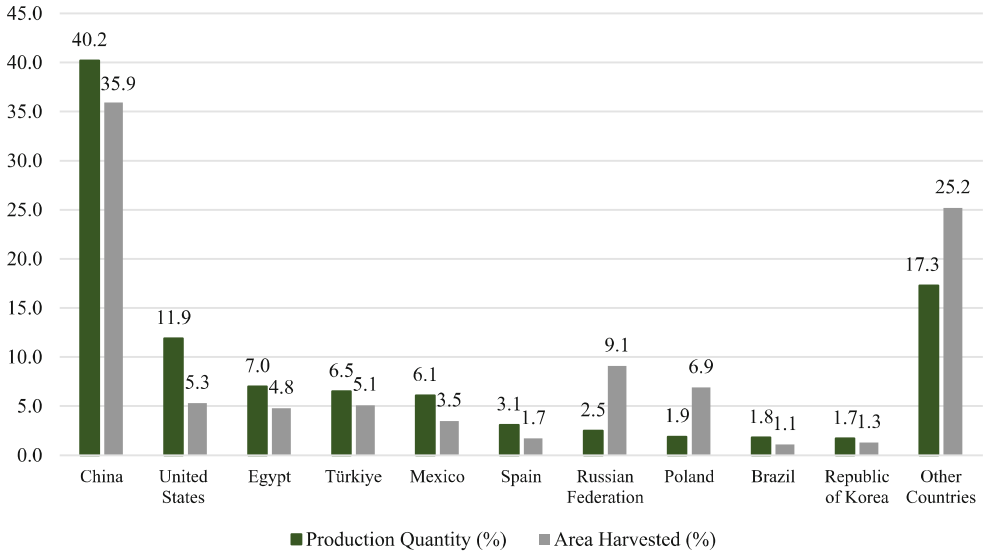

Fig. 2 Share of production quantity and harvested area among the top 10 strawberry-producing countries (FAOSTAT 2025); calculated by authors

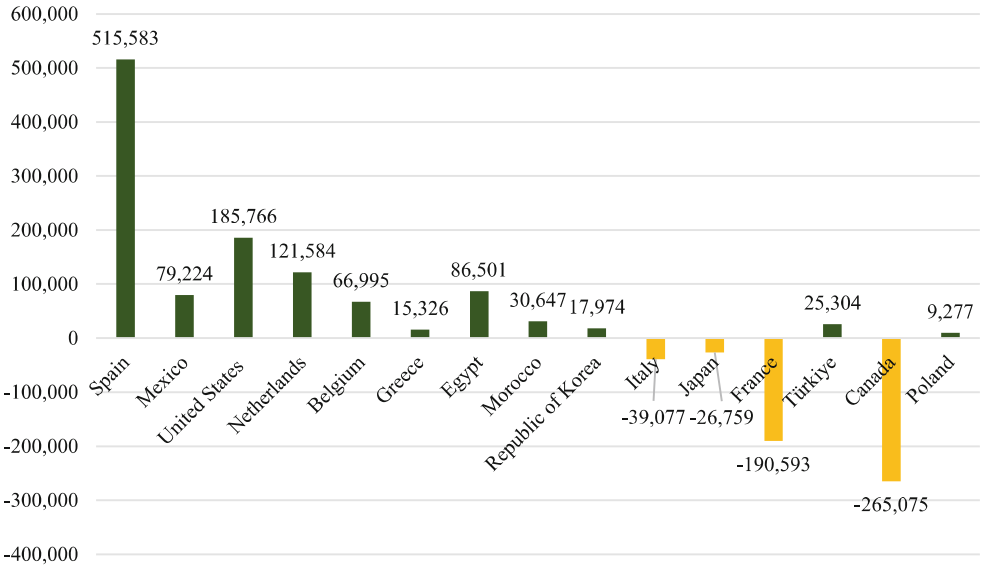

Fig. 3 Net export values of countries in 2009 (thousand USD) (FAOSTAT 2025); calculated by authors

countries. Possible reasons include climatic conditions, technological limitations, restricted access to production inputs, and insufficient agricultural knowledge infrastructure. These findings demonstrate that in strawberry production, not only the size of the cultivation area but also the implementation of efficient production techniques creates a competitive advantage (Fig. 2).

Figure 3 shows the net values of countries in strawberry trade in 2009, revealing the extent to which exports dominate over imports. In this context, Spain is clearly the leader with a positive net trade value of 515,583 USD; this indicates that the country not only carries out high-volume exports in strawberry production but also generates a surplus in the domestic market. Similarly, countries such as the United States, Mexico, the Netherlands, and Belgium also stand out with positive net trade values. Mexico's net value of 79,224 USD, in particular, demonstrates its competitive advantage in strawberry exports due to its proximity to the United States market and low labor costs. Türkiye, with a positive value of 25,304 USD, shows a moderate foreign trade surplus; while this is a positive signal, it indicates a more limited advantage compared to leading countries such as Spain and Mexico (Fig. 3).

Figure 4 also presents the net trade values of strawberry products for the year 2023. Here, countries such as Spain (716,368 USD) and Mexico (673,658 USD) appear to have further increased their net trade surpluses; this indicates that export volumes have grown during the year and that global demand has shifted in favor of these countries. The Netherlands (207,869 USD), Greece (163,504 USD) and Egypt (132,308 USD) also stand out with positive values. Türkiye's net trade value for 2023 is shown as (37,065 USD). On the other hand, countries such as the United

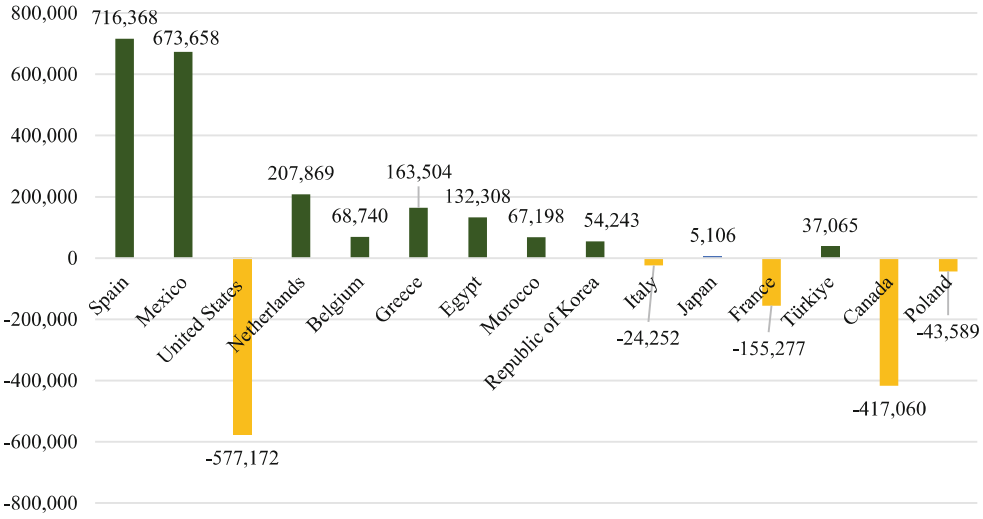

Fig. 4 Net export values of countries in 2023 (thousand USD) (FAOSTAT 2025); calculated by authors

Table 2 Foreign trade data and export-to-import coverage ratios for strawberry products by country in 2009 and 2023 (FAOSTAT 2025); calculated by authors

Years	2009			2023		
Countries	Export thousand ($)	Import thousand ($)	Coverage rate (%)	Export thousand ($)	Import thousand ($)	Coverage rate (%)
Spain	526,001	10,418	5049	757,620	41,252	1837
Mexico	93,164	13,940	668	749,155	75,497	992
United States	344,005	158,239	217	631,535	1,208,707	52
Netherlands	213,053	91,469	233	333,313	125,444	266
Belgium	162,885	95,890	170	175,715	106,975	164
Greece	18,517	3191	580	165,493	1989	8320
Egypt	86,510	9	961,222	132,308	0	*Net exporter*
Morocco	30,653	6	510,883	67,202	4	1,680,050
Republic of Korea	17,974	0	*Net exporter*	54,347	104	52,257
Italy	47,134	86,211	55	48,617	72,869	67
Japan	1703	28,462	6	43,867	38,761	113
France	63,573	254,166	25	39,954	195,231	20
Türkiye	25,304	0	*Net exporter*	37,130	65	57,123
Canada	757	265,832	0.28	32,473	449,533	7
Poland	19,247	9970	193	31,626	75,215	42

Import value = 0; coverage not computable—Net exporter

States, Italy, France, Canada, and Poland are net importers of strawberries, with negative net trade values (Fig. 4).

Table 2 presents the foreign trade data of the strawberry product for the years 2009 and 2023, comparatively revealing countries' export performance and import dependency. The export-to-import coverage ratio is a key indicator in determining whether countries are net exporters or importers in this context. In 2009, Spain was the clear leader in strawberry exports with a ratio of 5049%; although this ratio declined to 1837% in 2023, the country still maintains a strong trade surplus. Similarly, Mexico increased its ratio from 668% in 2009 to 992% in 2023, enhancing its export capacity. Countries such as Greece and Morocco reached exceptionally high coverage ratios in 2023–8320% and 1,680,050%, respectively, reinforcing their identities as net exporters in strawberry trade. Morocco, in particular, stands out with a high export value despite a low import volume (Table 2).

On the other hand, the United States became more import-dependent by reducing its coverage ratio from 217% in 2009 to 52% in 2023. Similarly, countries such as France, Canada, and Poland also show low ratios and are positioned as net importers in strawberry trade (Table 2). According to trade theory, a nation's ability to compete internationally is fundamentally based on its comparative advantages. When countries are compared, agricultural competitiveness is generally measured by differences in production costs (Nowak and Kaminska 2016).

Indeed, the factors determining agricultural competitiveness are multidimensional. Analyses conducted within the framework of Porter's diamond model reveal that variables such as land productivity, labor productivity, land availability, gross domestic product (GDP) per capita, producer support equivalent (PSE) values, WTO membership, and customs tariffs have significant relationships with competitiveness (Jambor and Babu 2016). Moreover, the level of agricultural productivity stands out as a key determinant of overall productivity, especially in low-income countries. Historically, increases in agricultural productivity have been a fundamental driving force behind development and economic growth (Gollin 2023). Türkiye was classified as a "net exporter" in 2009 due to the absence of imports; in 2023, it maintained this status with a notably high coverage ratio of 57,123%. Countries such as the Republic of Korea and Egypt were also classified as net exporters, as they did not engage in imports (Table 2).

In the study, RCA indices for strawberry exports were calculated for the countries examined from 2009 to 2023. The calculations are presented in Figs. 5, 6 and 7. While preparing the tables, the countries were ranked in descending order based on their export values in 2023. The RCA index values and 15-year averages for a total of 15 countries are provided below (Figs. 5, 6 and 7).

When examining the RCA index values for strawberry exports of countries during the 2009–2023 period, it is evident that Spain, Egypt, Morocco, Greece, and Mexico stand out prominently. Countries with an RCA value above 1 are considered to have a comparative advantage in this product, whereas those with values below 1 are not regarded as having such an advantage.

Fig. 5 Balassa's revealed comparative advantage index for strawberry (calculated by authors)

Years	Spain	Mexico	United States	Netherlands	Belgium
2009	16.41	2.88	2.31	3.04	3.12
2010	16.92	3.90	2.42	3.47	3.25
2011	17.34	3.47	2.36	3.89	3.12
2012	18.16	4.79	2.20	3.80	2.95
2013	15.82	4.45	2.39	4.16	2.95
2014	15.90	4.73	2.33	3.98	3.01
2015	16.48	4.55	2.23	2.89	3.25
2016	15.61	5.78	2.13	2.94	2.89
2017	14.23	7.17	2.10	3.00	2.92
2018	15.11	7.12	2.12	3.05	2.87
2019	14.00	8.55	1.92	2.57	2.83
2020	13.34	8.52	2.01	3.09	3.06
2021	13.92	9.57	2.07	2.76	2.33
2022	13.07	10.51	2.11	2.25	1.83
2023	12.04	8.50	2.10	2.40	2.10
Average	**15.22**	**6.30**	**2.19**	**3.15**	**2.83**

Fig. 6 Balassa's revealed comparative advantage index for strawberry (calculated by authors)

Years	Greece	Egypt	Morocco	Republic of Korea	Italy
2009	6.42	26.61	15.47	0.35	0.82
2010	11.56	14.85	12.17	0.44	1.16
2011	12.41	15.90	31.09	0.27	0.96
2012	11.58	20.80	17.96	0.32	0.86
2013	13.33	19.69	14.05	0.41	0.85
2014	13.25	22.71	11.11	0.45	0.65
2015	9.08	26.71	15.19	0.47	0.62
2016	7.65	26.93	12.71	0.46	0.61
2017	6.91	24.10	13.83	0.51	0.58
2018	7.66	19.92	12.19	0.56	0.48
2019	11.31	21.26	16.25	0.68	0.47
2020	14.10	17.82	14.02	0.62	0.44
2021	18.21	19.12	13.73	0.62	0.49
2022	17.47	17.55	12.02	0.61	0.47
2023	20.22	22.33	10.85	0.58	0.48
Average	**12.08**	**21.09**	**14.84**	**0.49**	**0.66**

Spain consistently maintained an RCA value in the 12–18 range throughout all years, demonstrating stable leadership in this field. This indicates that Spain possesses strong specialization in strawberry exports and a high level of competitiveness in the global market. However, a decline in RCA values has been observed in recent years (2021–2023); this may suggest either an increase in Spain's overall exports or a slower growth in strawberry exports compared to other countries. Mexico, on the other hand, raised its RCA value from 2.88 in 2009 to 8.50 in 2023, revealing a growing specialization in strawberry exports (Fig. 5).

These findings reveal that the competitive strength of countries in strawberry exports should be evaluated not only through indicators of comparative advantage but also in terms of long-term sustainability and market strategies. Indeed, Cossio and Flores (2021) examined the competitiveness of Mexican strawberries in the United States market during the 1992–2017 period using the Balassa index (RCA) and export openness degree; although Mexico maintained its competitive position, it experienced fluctuations after 2004 and entered a gradual decline in competitiveness, while Spain showed a similar downturn after 2006. These results demonstrate that even for major exporters, sustaining competitiveness over the long term remains a challenge. Additionally, in a study by Ninaquispe et al. (2025) on competitiveness and market diversification in global strawberry exports during the 2019–2023 period, it was found that Mexico exhibited high concentration by directing nearly all of its exports to the United States, whereas Spain showed a more balanced distribution by targeting alternative markets such as Germany, the United Kingdom, and France. In this study, which calculated the Herfindahl–Hirschman Index (HHI) and RCA index, it was noted that the United States, Canada, Mexico, and Saudi Arabia had a balanced export structure, while countries like the Netherlands and Belgium displayed moderate competitiveness indicators. However, this study did not include Greece, Egypt, and Morocco, which in our research showed very high RCA values (Fig. 6).

According to the RCA values calculated in the study, Egypt consistently exceeded an RCA value of 20 in most years, reaching the highest value of 22.33 in 2023. It also holds the highest 15-year average with a ratio of 21.09. This indicates that the country has gained strong specialization and a competitive advantage in strawberry exports. Morocco peaked in 2011 with a value of 31.09, but experienced fluctuations in subsequent years. Although its RCA value declined to 10.85 in 2023, it still maintains its comparative advantage. Greece, on the other hand, showed a steady

Fig. 7 Balassa's revealed comparative advantage index for strawberry (calculated by authors)

Years	Japan	France	Türkiye	Canada	Poland
2009	0.02	0.93	1.76	0.02	1.00
2010	0.02	0.77	2.02	0.03	1.06
2011	0.02	0.85	1.30	0.02	1.08
2012	0.02	0.87	1.03	0.03	0.93
2013	0.03	0.76	1.32	0.02	0.99
2014	0.05	0.65	0.87	0.03	0.99
2015	0.09	0.66	1.16	0.03	0.68
2016	0.11	0.54	0.37	0.03	0.61
2017	0.16	0.54	0.54	0.07	0.39
2018	0.23	0.47	1.05	0.10	0.30
2019	0.19	0.37	0.96	0.13	0.30
2020	0.23	0.43	0.87	0.13	0.34
2021	0.31	0.45	1.30	0.14	0.37
2022	0.39	0.45	0.91	0.28	0.51
2023	0.41	0.41	0.98	0.38	0.56
Average	**0.15**	**0.61**	**1.09**	**0.10**	**0.67**

increase after 2010 and reached a notable level of competitiveness with a value of 20.22 in 2023 (Fig. 6).

On the other hand, countries such as the United States, the Netherlands, and Belgium, while showing a certain level of specialization in strawberry exports with RCA values ranging between 1 and 4, remain behind the leading countries in terms of comparative advantage. Although their strawberry export volumes are strong, their share in overall competitiveness remains relatively low (Fig. 5).

Türkiye remained below an RCA value of 1 in many years, surpassing 1 only in 2009–2013, 2015, 2018, and 2021. This indicates that Türkiye's comparative advantage in strawberry exports is relatively weak compared to other countries. The main reason is thought to be Türkiye's preference for domestic consumption of strawberry production and its strategy of exporting through value-added food products. However, as the world's fourth-largest strawberry producer, Türkiye holds significant potential. To enhance competitiveness, investments in production efficiency, quality, and export strategies are essential. Countries such as the Republic of Korea, Japan, France, and Canada remained below an RCA value of 1 throughout the entire period, indicating that they do not possess a comparative advantage in strawberry exports. Although Italy in 2010 and Poland between 2009 and 2011 showed superiority, it was determined that they lacked comparative advantage in all other years (Figs. 6 and 7).

In conclusion, although the countries with comparative advantage in strawberry exports have varied over time, Egypt, Spain, Morocco, Greece, and Mexico have emerged as leading players in this field. Particularly, the rising RCA values of Egypt and Greece in recent years are noteworthy. Compared to these countries, Türkiye holds a weaker position in strawberry exports, and it is essential to take strategic steps to improve this situation.

In the study, countries with RCA values consistently above 1 over the years—Spain, Mexico, the United States, the Netherlands, Belgium, Greece, Egypt, and Morocco—were compared in pairs (Figs. 8 and 9). This approach provided clearer insights into which countries are more competitive.

While Spain's traditional leadership is weakening, Mexico's rising RCA performance indicates that it has strengthened its competitive position in the global market. The volatility in the Netherlands' performance reflects sensitivity to external markets, whereas the stable RCA value of the United States may point to a production structure focused on domestic consumption (Fig. 8). Greece's upward RCA trend demonstrates the success of its transformation in agricultural export strategies and integration into foreign markets. Egypt maintains its regional leadership in strawberry exports, while Morocco's declining RCA performance suggests a need to restructure its export strategies. According to the data, Egypt is the country that has sustained the highest and most stable comparative advantage in strawberry

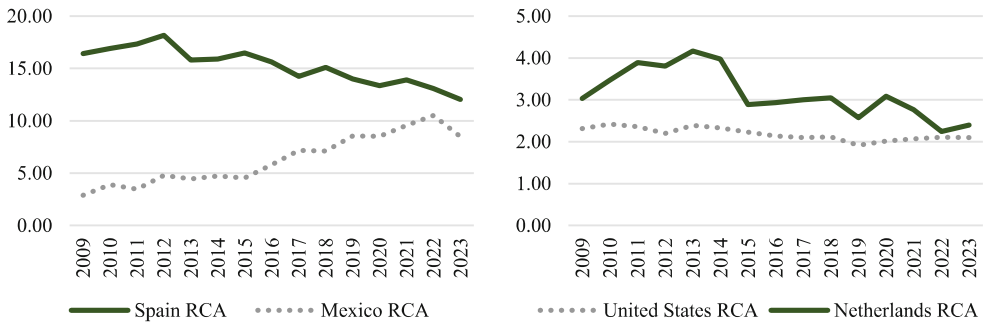

Fig. 8 Comparison of revealed comparative advantage (RCA) values of selected countries in strawberry trade (2009–2023) (Spain–Mexico, United States–Netherlands)

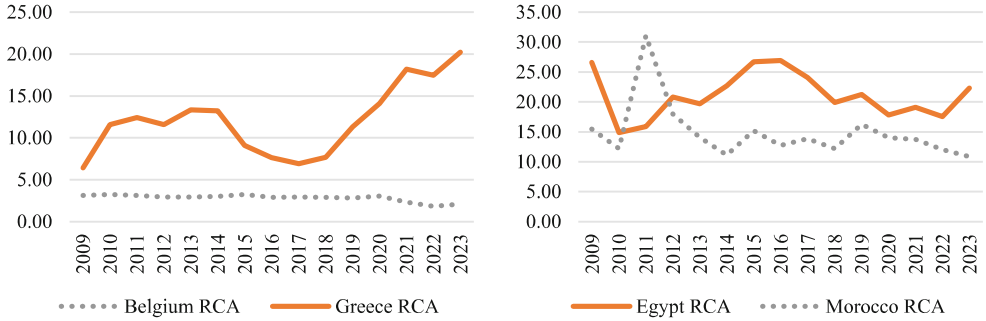

Fig. 9 Comparison of revealed comparative advantage (RCA) values of selected countries in strawberry trade (2009–2023) (Belgium–Greece, Egypt–Morocco)

exports. Over the 15-year period, its RCA value remained above 20 in most years. As of 2023, it holds the highest RCA value at 22.33. This indicates that Egypt has the highest level of specialization and global competitiveness in strawberry exports (Fig. 9). A recent study has reported similar findings. Attia et al. (2024) analyzed the competitiveness of frozen Egyptian strawberries using RCA, market share, price competition, and gravity model. The results showed that Egypt achieved a very strong RCA (average RCA >40 between 2018 and 2022) and significantly increased its market share in key markets such as Germany, Russia, and Saudi Arabia. The study also emphasized that export prices are the most influential factor in determining competitiveness, followed by Egypt's GDP and geographical distance.

Conclusion

In this study, the competitiveness of 15 leading countries in global strawberry exports during the 2009–2023 period was evaluated using the revealed comparative advantage (RCA) index. Supported by export-to-import coverage ratios and net export values, a comprehensive trade analysis was presented. The findings indicate that competitive positioning in strawberry exports depends not only on production volume, but also on integration into foreign markets, logistics infrastructure, quality standards, and trade policies.

In the study, it was determined that the countries with RCA values consistently above 1 over the years include Spain, Mexico, the United States, the Netherlands, Belgium, Greece, Egypt, and Morocco. Among these, Egypt, Spain, Morocco, Greece, and Mexico demonstrated stable and high performance in terms of RCA values throughout the examined period, thereby proving their comparative advantage in the global market. In particular, Egypt maintained an RCA value well above 1 in all analyzed years, reaching a leading position in terms of both stability and competitiveness. This can be explained by factors such as Egypt's low production costs, favorable climatic conditions, early harvest advantage, and proximity to the European market. Other studies conducted also support this situation.

Among the countries examined, Türkiye ranks among the world's top five in production volume, yet its RCA values remained below 1 in most years and sustainable competitive advantage was not achieved. This situation indicates a need for greater investment and strategic planning in Türkiye's export policies, particularly in the development of higher value-added products, branding, logistics optimization, and access to foreign markets. In addition, regional clustering support and incentives for cold-chain investments should be implemented to enhance producers' and firms' innovation capacity and export orientation.

The findings of the study reveal that, in order to enhance competitiveness in strawberry exports, countries must consider not only production volume but also the structure of exports, target markets, and trade policies. The changes in RCA values over time reflect the transformation of countries' foreign trade strategies and their positioning in the global market.

On the other hand, the stability of the RCA of countries such as Egypt, Spain, Morocco, Greece, and Mexico—characterized by high RCA values and consistent export performance—supports the classical theoretical assumptions of specialization and competitiveness based on Ricardo's theory of comparative advantage. It also demonstrates that a strong position in high-income markets can help offset fluctuations in agricultural product supply.

Data availability statement Data will be made available upon reasonable request

Declarations

Conflict of interest A. Durmuş, B. Ayyıldız and G. Erdal declare that they have no competing interests.

Ethical standards For this article no studies with human participants or animals were performed by any of the authors. All studies mentioned were in accordance with the ethical standards indicated in each case.

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