

Comparative advantage of citrus fruits exported from emerging countries to the United States, 2005–2024

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This study analyzes the revealed comparative advantage (RCA) of citrus exports from the main exporting countries to the U.S. market during the period 2005–2024. The specific objectives were to identify the revealed comparative advantage (RCA) of the main exporters (Peru, Mexico, and Colombia) to the U.S. market during the same period. The methodology used is applied, with a descriptive quantitative approach, a non-experimental design, and a longitudinal cross-sectional framework. The data set consisted of citrus export data (2005–2024) compiled from the TRADE MAP platform. The results showed that Peru achieved the highest revealed comparative advantage, with an average of 2.11, peaking at 4.36 in 2022. In comparison, Mexico obtained an RCA of 1.14 and Colombia recorded 1.07. It is concluded that Peru ranks as the leading country in terms of competitiveness and export specialization, confirming the proposed hypothesis.

Keywords: Revealed comparative advantage, exports, citrus, international trade.

I. INTRODUCTION

International trade is a key driver of economic development for many countries, particularly for economies with high agricultural export potential, such as Peru. This not only increases export revenues but also diversifies production and strengthens strategic sectors. In Peru, agricultural exports have taken on a leading role, driving growth in agricultural regions and improving the country's international competitiveness [1].

According to the TRADE MAP platform [2], Peruvian exports to foreign countries reached \$361,084,000 in 2024 under tariff heading "0805," which covers citrus fruits. This makes the country one of the leading exporters of this product group to the United States, with a growing share of the international fresh fruit trade.

In 2023, Mexico consolidated its position as one of the leading citrus exporters, recording exports exceeding \$600 million to the U.S. market, reflecting its high production capacity and its established role as a strategic supplier in that market [3].

Colombia has seen significant growth in its citrus exports, with annual increases of more than 10% in both

value and volume in recent years, driven by the expansion of its cultivated area and by trade agreements such as the Free Trade Agreement with the United States, which grants preferential market access to a large portion of its production [4].

In Peru, citrus fruits have established themselves as a key component of the agricultural export basket, standing out for their strong performance in international markets [5]. In this context, citrus fruits, has become one of the most important items in the agricultural export basket. During the first quarter of 2023, 13,515 tons were exported, worth 14 million U.S. dollars, representing a 51% increase in volume and a 38% increase in value compared to the same period in 2022. However, increased supply drove international prices down by 8%, to \$1.04 per kilogram.

In 2023, the citrus fruit category, emerged as one of Peru's top export products, with a 23% increase over the previous year, despite adverse weather conditions. Production was concentrated mainly in Piura and Lambayeque, with the United States as the primary destination, followed by Chile, the United Kingdom, and Italy [6].

Similarly, citrus production remains a key activity in regions such as Piura, Tumbes, and Lambayeque, which together account for 88% of national production. In 2024, [7] production increased by 13% compared to 2023, although there were challenges related to falling prices and reduced income for producers, particularly in Piura, where prices dropped by as much as 51%.

Despite the sustained growth in Peruvian citrus exports, as evidenced by the performance of lemons [8], the country continues to face production and market constraints that limit its competitiveness, highlighting the need to assess its true comparative advantage in the U.S. market.

Based on the above, the following general research question is posed: What is the revealed comparative advantage of citrus exports from the main exporting countries to the U.S. market during the period 2005–2024?

This leads to the following general objective: 1). Determine the revealed comparative advantage of citrus exports from the main exporting countries to the U.S. market during the 2005–2024 period, while the specific objectives are: 2). Identify the revealed comparative

advantage of Peruvian citrus exports to the U.S. market during the 2005–2024 period, 3). Identify the revealed comparative advantage of Mexican citrus exports to the U.S. market during the 2005–2024 period; and finally, 4). Identify the revealed comparative advantage of Colombian citrus exports to the U.S. market during the 2005–2024 period.

Regarding the background, international and national studies related to export competitiveness and the measurement of revealed comparative advantage in agricultural products were cited. According to the author [9], who analyzed the competitiveness of Mexican avocado exports using revealed comparative advantage to assess the country's position in international trade between 2003 and 2020, this study focused on measuring export specialization, traceability, and the relationship with the U.S. market, using indicators that identify Mexico's share in global trade of the product and its degree of consolidation as an international supplier.

Similarly, various studies highlight the competitiveness of agricultural products in international trade. Mexican mangoes maintain an exportable surplus and self-sufficiency in production, which strengthens their competitiveness in international markets and their ability to meet both domestic and foreign demand [10].

Furthermore, Brazilian citrus and their competitors are highly competitive on the global market, with the United States being the leading importer and positioning Brazil as a major player in the global trade [11].

On the other hand, Mexican bananas continue to show steady growth and maintain a strong presence in domestic and international markets, reflecting their export capacity [12].

In this context, Mexico is also positioning itself as a potential exporter of citrus, with the capacity to meet both domestic and international demand, and showing a growing trend in its international shipments [13].

Similarly, Mexican tomatoes have established a strong presence in the U.S. market, bolstered by trade agreements such as the USMCA [14].

However, not all products perform equally well in terms of competitiveness. Evidence shows that the competitiveness of Mexican coffee in the international market declined between 2000 and 2019, with a decrease in its market share relative to countries such as Brazil and Peru, while Colombia maintained a stable position [15].

Finally, it should be noted that citrus cultivation in Mexico is highly specialized and concentrated in specific regions, making the country a net exporter, with the United States as its main trading partner [16].

In Huila, only coffee and cocoa have significant comparative advantages; coffee is exported to strategic markets such as the United States, while other agricultural products are less competitive [17].

Furthermore, it has been demonstrated that exports of agricultural products such as avocados and grapes from Arequipa offer comparative and competitive advantages in international markets, establishing the region as a leader in production and exports, with the United States as the primary destination [18].

The general hypothesis is formulated as follows: There is a revealed comparative advantage for Peruvian citrus exports to the U.S. market compared to the main suppliers to that market—Mexico and Colombia—during the period 2005–2024.

II. THEORETICAL FRAMEWORK

With regard to the theoretical foundations of this study, the theories underpinning the variables under investigation were examined. In this regard, revealed comparative advantage is based on the theory proposed by Béla Balassa in 1965 [19], which posits that this indicator allows for the measurement of a country's degree of export specialization in a specific product relative to other countries in international trade. According to this approach, when the revealed comparative advantage index is equal to or greater than 1, it is interpreted that the country specializes in the export of that product.

The formula for the aforementioned index is as follows:

$$IVCR = \frac{\frac{X_{ij}}{\sum_i^n X_{ij}}}{\frac{\sum_j^n X_{ij}}{\sum_{ij}^n X_{ij}}} - \frac{\frac{I_{ij}}{\sum_i^n I_{ij}}}{\frac{\sum_j^n I_{ij}}{\sum_{ij}^n I_{ij}}}$$

$$IVCR = VCEai - VCIai$$

Where:

$VCEai$ = Revealed comparative advantage (exports)
 $VCIai$ = Revealed comparative advantage (imports)

Similarly, Balassa proposed a formula for a more specific calculation of the RCEV, which was used in this research:

$$VCRE = \frac{\frac{X_j^i}{X_{ij}^T}}{\frac{X_w^i}{X_{iw}^T}}$$

Where:

X_j^i = Exports of the product α made by the country i to the country (j) .
 X_{ij}^T = Total exports of the product i from country to country (j) .
 X_w^i = Exports of the product α made by the country i to the world (w) .
 X_{iw}^T = Total exports from the country i to the world (w) .

In addition, we considered the theory of revealed comparative advantage in exports—or the revealed competitiveness index—proposed by Thomas Vollrath in 1991 [20], which offers an alternative method for assessing a country's degree of specialization in a specific product. This approach allows for comparing a country's exports with global trade performance, facilitating the

identification of sectors in which it exhibits higher levels of competitiveness.

Similarly, this variable is based on the theory of comparative advantage proposed by David Ricardo in 1817 [21], who argued that each nation should specialize in the production and export of those goods in which it possesses greater relative efficiency, in order to optimize its participation in international trade.

Furthermore, with regard to exports, we draw on Paul Krugman's new theory of international trade [22], which explains trade between countries with similar characteristics based on product differentiation and economies of scale. This approach suggests that trade arises even in contexts of imperfect competition, where economies of scale allow for cost reductions and geographic location can generate competitive advantages.

In this context, Adam Smith's theory of absolute advantage [16] states that a country has an advantage when it can produce a good using fewer resources than another country. It also emphasizes that specialization and the division of labor facilitate the export of surpluses and the import of goods that are less efficiently produced domestically.

For its part, the Heckscher-Ohlin model [23] posits that international trade arises from differences in the endowment of production factors, such that each country exports goods that are intensive in the resources it possesses in abundance and imports those that require scarce factors. This model expands on the theory of comparative advantage by offering a more structured explanation of cost differences between countries.

Similarly, the theory of the benefits of free trade, associated with Samuelson [24], argues that trade liberalization promotes specialization based on comparative advantage, which contributes to increased efficiency and economic well-being. However, it should be noted that these benefits depend on specific conditions and require public policy interventions to mitigate market failures and distribute the benefits equitably.

Finally, the theory of firm heterogeneity, developed by Melitz [25], suggests that only the most productive firms are able to overcome barriers to entry and compete in international markets. This approach allows us to understand the process of internationalization from a microeconomic perspective, highlighting the role of firm productivity in generating sustainable competitive advantages.

III. METHODOLOGY

A. Type and design of the research

This research is applied in nature, as it seeks to link scientific knowledge with practice, offering a possible solution to the problem [26].

A quantitative approach was used, which is based on the collection and analysis of numerical data in order to measure and describe variables [27].

The design adopted was non-experimental [28], which differs in that this design does not manipulate variables and only seeks to observe, describe, and analyze information as

it occurs in reality. It is ex post facto because it analyzes events that have already occurred without intervening in them.

It is also a longitudinal study, as it examines the evolution of exports at different points in time between 2005 and 2024 [29].

Finally, it has a descriptive scope, the purpose of which is to detail the characteristics of the phenomenon studied, focusing on collecting important information on each of the variables [30].

B. Variables and operationalization

The first variable is revealed comparative advantage, defined as an economic indicator that measures the level of competitiveness of a product from a given country in relation to the global market Balassa [9].

The dimensions are made up of (1) RCEV of Peru, (2) RCEV of Mexico, and (3) RCEV of Colombia.

For the second variable, exports [31], it mentions that this refers to the sale of goods and services produced in a country for the international market, playing a key role in the development of the country's economy.

The following were measured: (1) Peruvian citrus exports, (2) Mexican citrus exports, and (3) Colombian citrus exports. This is a quantitative study using a ratio scale.

C. Population, sample, and sampling

With regard to the study population, [32] the author mentions that the population is one that includes elements, animals, and people that have interesting characteristics that can be used for analysis. That is why; in order to define this population, inclusion and exclusion criteria were established to ensure the relevance and reliability of the information and thus avoid bias in the analysis of the results. Thus, the study population consisted of export data from Peru, Mexico, and Colombia to the United States between 2005 and 2024.

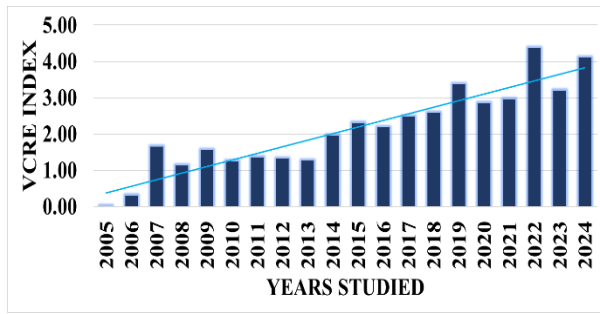
D. Data collection techniques and instruments

Documentary analysis was used as the data collection technique, as it allows for the collection of relevant, verifiable, and reliable information. Meanwhile, the documentary file was used as the instrument, which served as a useful tool for organizing, classifying, and analyzing key information [33].

It is important to note that in this case, no reliability test was applied, nor were any instruments validated.

A hypothetical-deductive analysis method was applied, which consisted of formulating a hypothesis and then testing it through observation and empirical analysis. If the hypothesis withstands the tests, it is considered provisionally valid, but if it is refuted, it is immediately rejected [34].

IV. RESULTS



With regard to specific objective 1, to identify the revealed comparative advantage of Peruvian citrus exports to the US market in the period 2005 to 2024, the following was identified:

TABLE 1
PERUVIAN EXPORT FIGURES FOR THE
CALCULATION OF THE VCRE

PERU - UNITED STATES (IN USD)					
YEARS	INDICATORS				
	Xij	Xtij	Xiw	Xtiw	VCRE
2005	14,000	5,257,260,000	18,400,000	17,114,289,000	0.00
2006	1,733,000	5,707,487,000	23,348,000	23,764,897,000	0.31
2007	11,331,000	5,585,918,000	34,460,000	28,084,585,000	1.65
2008	10,528,000	5,835,264,000	49,767,000	31,288,212,000	1.13
2009	11,548,000	4,603,773,000	43,117,000	26,738,260,000	1.56
2010	13,199,000	7,030,970,000	57,609,000	38,402,213,000	1.25
2011	13,272,000	6,272,046,000	72,464,000	46,386,022,000	1.35
2012	17,220,000	8,205,655,000	84,010,000	52,436,073,000	1.31
2013	23,649,000	9,209,547,000	97,578,000	48,114,379,000	1.27
2014	37,822,000	6,253,910,000	119,665,000	38,645,855,000	1.95
2015	42,328,000	5,020,220,000	122,143,000	33,246,845,000	2.30
2016	54,883,000	6,235,293,000	145,804,000	36,039,994,000	2.18
2017	73,943,000	6,935,897,000	190,658,000	44,237,949,000	2.47
2018	86,963,000	7,837,624,000	202,746,000	47,223,269,000	2.58
2019	85,567,000	5,551,812,000	206,882,000	45,135,222,000	3.36
2020	127,831,000	6,240,574,000	279,401,000	38,757,234,000	2.84
2021	100,039,000	7,192,891,000	264,850,000	56,260,115,000	2.95
2022	162,009,000	8,655,783,000	273,037,000	63,648,101,000	4.36
2023	124,593,000	9,229,714,000	273,210,000	64,605,821,000	3.19
2024	189,403,000	9,554,345,000	361,084,000	74,664,216,000	4.10
AVERAGE	118,787,500	13,641,598,300	292,023,300	85,479,355,100	2.11

Source: Prepared by the authors using FOB values for Peruvian exports obtained from the TRADE MAP platform.

Table 1 shows that Peruvian exports grew significantly during the period 2005–2024. First, exports of citrus to the United States rose from very low levels to rapid increases

from 2012 onwards, demonstrating their consolidation as an increasingly competitive product.

Likewise, Peru's total exports to that market follow an upward trend, although they registered a slight decline in 2014 y 2019, but still confirm the strategic importance of the United States as a commercial destination. Similarly, Peru's exports of citrus to the world show a sustained increase, reaching their highest value in 2024, despite a decline in 2021 due to external factors.

Fig. 1. VCRE of Peruvian citrus to the US market (2005-2024)

The results indicate that Peru began the period with VCRE indices below 1 during the first two years, reflecting low initial competitiveness. In 2007, the country exceeded this threshold with an index of 1.65, marking the beginning of a process of consolidation in its comparative advantage. Subsequently, the VCRE reached its maximum value of 4.36 in 2022, driven by strong post-pandemic global demand and production expansion. In 2023, the index fell slightly to 3.19 due to increased competition and lower international demand, confirming that Peru maintains a consolidated comparative advantage in its citrus exports to the United States.

In relation to the results of specific objective 2, Identifying the revealed comparative advantage of Mexican citrus exports to the US market in the period 2005 to 2024, the following results were obtained:

TABLE 2
MEXICAN EXPORT FIGURES FOR THE
CALCULATION OF THE VCRE

MEXICO - UNITED STATES (IN USD)					
YEARS	INDICATORS				
	Xij	Xtij	Xiw	Xtiw	VCRE
2005	159,425,000	183,837,713,000	171,099,000	214,207,306,000	1.09
2006	192,845,000	212,131,773,000	208,177,000	249,960,546,000	1.09
2007	225,023,000	223,387,835,000	244,919,000	271,821,215,000	1.12
2008	241,673,000	233,793,948,000	262,888,000	291,264,809,000	1.15
2009	189,162,000	185,448,519,000	208,010,000	229,712,337,000	1.13
2010	228,327,000	238,858,912,000	258,806,000	298,305,075,000	1.10
2011	243,102,000	274,720,113,000	272,802,000	349,326,582,000	1.13
2012	218,781,000	288,176,389,000	285,748,000	370,706,658,000	0.98
2013	264,284,000	299,486,781,000	296,766,000	379,949,273,000	1.13
2014	346,155,000	318,652,628,000	375,620,000	396,890,473,000	1.15
2015	356,156,000	309,191,752,000	393,346,000	380,789,105,000	1.12
2016	417,086,000	302,971,281,000	468,200,000	373,904,303,000	1.10
2017	510,146,000	327,375,073,000	564,402,000	409,476,446,000	1.13
2018	534,721,000	344,915,168,000	591,311,000	450,920,374,000	1.18
2019	562,477,000	358,638,540,000	603,126,000	460,603,696,000	1.20
2020	518,686,000	330,433,646,000	555,216,000	416,982,170,000	1.18
2021	728,964,000	386,168,160,000	755,609,000	494,460,765,000	1.24

2022	797,304,000	452,294,119,000	815,900,000	577,730,713,000	1.25
2023	867,439,000	474,696,156,000	883,063,000	593,707,209,000	1.23
2024	878,706,000	503,263,783,000	890,124,000	618,982,287,000	1.21
AVERAGE	848,046,200	624,844,228,900	910,513,200	782,970,134,200	1.14

Source: Prepared internally using FOB values for Mexican exports obtained from the TRADE MAP platform.

Table 2 shows that Mexican exports of citrus to the United States remain stable and high in volume between 2005 and 2024. First, export values (X_{ij}) remain consistently high and show moderate increases throughout the period, demonstrating Mexico's strong commercial presence in this market.

Likewise, Mexico's total exports to the United States (X_{tij}) show an upward trend, especially since 2017, reflecting a consolidation of the commercial link between the two countries.

Similarly, global export of citrus (X_{iw}) and total global exports (X_{tiw}) show continuous increases, placing Mexico within an international context of expansion for the product.

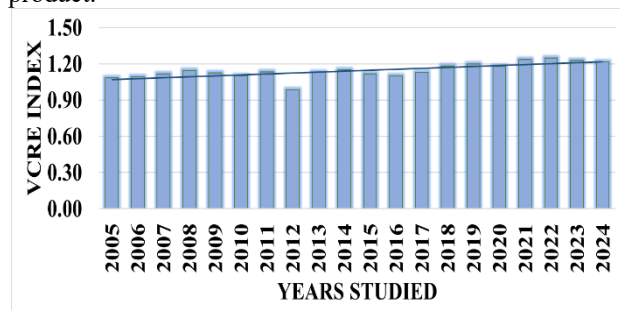


Fig. 2. VCRE of Mexican citrus to the market (2005-2024)

In terms of performance, the VCRE for Mexican citrus in the United States remained above 1 between 2005 and 2011, showing moderate specialization. In 2012, the index declined due to structural challenges that put downward pressure on it in some segments, but recovered from 2013, increasing by 0.15 points compared to the previous year. The highest peak was recorded in 2022 with 1.25, driven by high demand and Mexico's geographical advantage. Despite this improvement, the country has not yet consolidated its position as a leading supplier ahead of Peru.

With regard to specific objective 3, identifying the revealed comparative advantage of Colombian citrus exports to the US market in the period 2005 to 2024, the following results were obtained:

TABLE 3
COLOMBIAN EXPORT FIGURES FOR THE
CALCULATION OF THE VCRE

COLOMBIA - UNITED STATES (IN USD)					
INDICATORS					
years	X_{ij}	X_{tij}	X_{iw}	X_{tiw}	VCRE
2005	523,000	8,851,631,000	2,219,000	21,190,439,000	0.56
2006	1,530,000	9,948,230,000	3,320,000	24,390,975,000	1.13
2007	1,739,000	10,609,167,000	5,528,000	29,991,332,000	0.89

2008	1,025,000	14,288,833,000	6,840,000	37,625,882,000	0.39
2009	263,000	13,123,466,000	5,374,000	32,852,986,000	0.12
2010	1,725,000	17,143,277,000	5,374,000	39,819,529,000	0.75
2011	858,000	21,948,535,000	3,203,000	56,953,516,000	0.70
2012	370,000	22,216,238,000	2,768,000	60,273,618,000	0.36
2013	357,000	18,692,895,000	3,809,000	58,821,870,000	0.29
2014	5,675,000	14,470,697,000	12,734,000	54,794,812,000	1.69
2015	2,390,000	10,052,617,000	9,417,000	35,690,767,000	0.90
2016	3,044,000	10,215,894,000	9,468,000	31,095,444,000	0.98
2017	4,362,000	10,975,962,000	17,000,000	37,770,123,000	0.88
2018	9,887,000	11,080,579,000	29,629,000	41,769,699,000	1.26
2019	10,873,000	12,265,471,000	33,321,000	39,496,225,000	1.05
2020	13,418,000	9,442,028,000	43,991,000	31,045,676,000	1.00
2021	26,450,000	11,549,621,000	60,575,000	40,488,600,000	1.53
2022	53,832,000	15,380,933,000	90,617,000	57,259,330,000	2.21
2023	68,779,000	13,922,127,000	103,151,000	49,542,894,000	2.37
2024	105,794,000	14,984,412,000	145,991,000	49,551,988,000	2.40
AVERAGE	31,289,400	27,116,261,300	59,432,900	83,042,570,500	1.07

Source: Prepared internally using FOB values for Colombian exports obtained from the TRADE MAP platform.

Table 3 shows that Colombian exports to the United States follow a general upward trend over the 2005–2024 period, although with occasional fluctuations. In the early years, the figures remain relatively moderate, and even show a degree of stability that could be perceived as relative stagnation. However, starting in 2021, much more dynamic growth is observed, reflecting notable commercial success. This uptick suggests the possible consolidation of new export products, greater market openness, or a significant shift in U.S. demand for Colombian products. Overall, the table shows a progressive strengthening of the trade relationship between Colombia and the United States, with export performance improving steadily over the period analyzed.

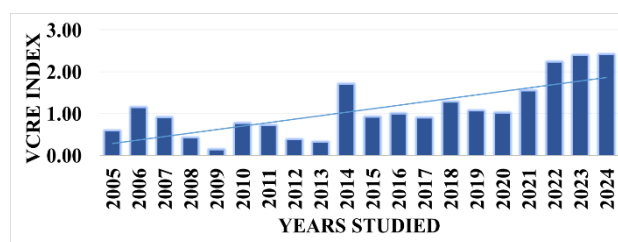


Fig. 3. VCRE of Colombian citrus to the US market (2005-2024)

The VCRE of Colombian citrus to the United States increased from 0.56 in 2005 to 2.40 in 2024, showing a significant improvement in competitiveness. Between 2005 and 2009, there were slight declines due to logistical problems, high transportation costs, and competition from Mexico. Since 2021, the index has grown steadily thanks to the TLC with the US, improvements in infrastructure, and productive diversification.

Regarding the overall objective, which is to determine the revealed comparative advantage of citrus exports from

the main exporting countries to the US market in the period 2005 to 2024, the findings revealed the following:

TABLE 4
EVOLUTION OF THE RCE OF CITRUS EXPORTS
FROM PERU, MEXICO, AND COLOMBIA TO THE
US 2005-2024.

Exporting countries	Peru	Mexico	Colombia
2005	0.00	1.09	0.56
2006	0.31	1.09	1.13
2007	1.65	1.12	0.89
2008	1.13	1.15	0.39
2009	1.56	1.13	0.12
2010	1.25	1.10	0.75
2011	1.35	1.13	0.70
2012	1.31	0.98	0.36
2013	1.27	1.13	0.29
2014	1.95	1.15	1.69
2015	2.30	1.12	0.90
2016	2.18	1.10	0.98
2017	2.47	1.13	0.88
2018	2.58	1.18	1.26
2019	3.36	1.20	1.05
2020	2.84	1.18	1.00
2021	2.95	1.24	1.53
2022	4.36	1.25	2.21
2023	3.19	1.23	2.37
2024	4.10	1.21	2.40
Average	2.11	1.14	1.07

Source: Prepared by the author using data obtained from TRADE MAP.

Table 4 shows the evolution of the RCE of countries exporting citrus to the United States over the last 20 years, as well as the average for each country. It can be seen that Peru recorded the highest average (2.11), followed by Mexico (1.14) and finally Colombia (1.07).

Therefore, the hypothesis is accepted, since Peru was the country with the highest VCRE. It can therefore be concluded that Peru has a greater revealed comparative advantage in its exports, standing out in terms of competitiveness and specialization in exports.

V. DISCUSSION

With regard to the objective of determining the revealed comparative advantage (RCA) of citrus exports from the main exporting countries to the U.S. market during the 2005–2024 period, the results show that the three countries analyzed have an RCA greater than one, confirming the existence of a positive comparative advantage in all cases. However, the magnitude of this

advantage varies significantly, with Peru being the country with the highest level of export specialization (2.11), followed by Mexico (1.14) and Colombia (1.07), reflecting differences in their competitiveness structures.

Peru's leading position indicates a high degree of specialization in citrus exports, which is consistent with David Ricardo's theory of comparative advantage—which holds that countries tend to focus on those goods in which they exhibit greater relative efficiency [21]—as well as with the approach to measuring revealed comparative advantage proposed by Béla Balassa [19]. This result can be explained by the dynamism of Peru's agro-export sector and the growing diversification of its product range, factors that contribute to improving its position in international trade [31]. Likewise, efficiency in the supply chain and logistics management have been identified as key elements for strengthening competitiveness in global markets [36], [37].

In the case of Mexico, the index of 1.14 reflects a stable revealed comparative advantage, underpinned by its consolidation as an agricultural exporter and its ability to maintain an exportable surplus that allows it to supply both the domestic and foreign markets [10]. Furthermore, its track record in international trade and its export potential for agricultural products, including citrus fruits, underpin its sustained presence in the U.S. market [13].

For its part, Colombia has an index of 1.07, indicating a positive comparative advantage, although it is closer to the minimum threshold for specialization. This trend can be linked to a process of gradual growth in its export sector, driven by the expansion of its production and its integration into international trade, which aligns with studies highlighting its increased competitiveness in recent years [11], as well as its performance relative to other Latin American countries [38].

From a theoretical perspective, these results can also be interpreted in light of Paul Krugman's new theory of international trade, which emphasizes the role of economies of scale and productive differentiation in countries' competitiveness [22]. In this regard, Peru's stronger performance suggests progress in these areas, while Mexico and Colombia maintain more stable levels of competitiveness or are in the process of consolidation.

Finally, it is concluded that, although all three countries exhibit a revealed comparative advantage in citrus exports, there are significant differences in their level of specialization, highlighting the need to strengthen structural aspects such as productivity, logistics, and export diversification in order to enhance competitiveness in the U.S. market.

VI. CONCLUSIONS

In relation to specific objective 1, it was identified that Peru obtained a high VCRE of 2.11, thus showing a solid and competitive position compared to other countries.

Regarding specific objective 2, it was concluded that Mexico reached a value of 1.14, reflecting a medium level of competitiveness compared to the other countries analyzed. This finding showed that, although Mexico

participated in the market, its degree of specialization was more limited during the period studied.

With regard to specific objective 3, Colombia recorded lower scores than other countries mentioned, reaching a low score of 1.07, which indicates lower competitiveness compared to Peru and Mexico.

Finally, in concluding the general objective of the research, which focused on determining the revealed comparative advantage of citrus exports from the main exporting countries to the US market between 2005 and 2024, the following values were obtained: Peru recorded a VCRE of 2.11, Mexico 1.14, and Colombia 1.07.

RECOMMENDATIONS

It is recommended that institutions involved in international trade in Peru, Mexico, and Colombia strengthen technical cooperation among countries through agreements aimed at disseminating good agricultural practices, which would help consolidate public policies [15]. Likewise, it is recommended that they promote initiatives focused on promotion, technological innovation, and sustainability in citrus production and export, with the aim of continuing to increase their competitiveness in strategic markets [35].

In Peru, it is essential that MINCETUR and MIDAGRI strengthen their support for producers and exporters by modernizing the supply chain and logistics through technological advancements. To this end, it is recommended that investments be prioritized with the aim of improving efficiency, ensuring the quality of citrus fruits, and reducing losses. Likewise, it is key to ensure compliance with the phytosanitary and quality standards required by the U.S. market, as well as to promote product diversification and innovation, which will allow Peru to maintain its leadership as the leading exporter to that market and strengthen its competitiveness against other countries [36].

For Mexico, it is in the best interest of companies involved in the export of citrus to consolidate their position in the U.S. market through continuous improvement of their logistics and commercial processes. Similarly, the government should promote technical training programs for producers, aimed at refining their agricultural practices and strengthening their ability to respond to adverse weather events and pests. The incorporation of environmental monitoring technologies and sustainable approaches would help sustain and enhance their competitiveness in the international market [37].

In the case of Colombia, it is recommended that entities involved in foreign trade and exporting companies closely monitor trade indicators, as these help identify changes in their level of competitiveness. Given their relatively weaker performance, this analysis should be complemented by the implementation of strategies aimed at improving their positioning, such as optimizing production and logistics processes, adopting technologies, and enhancing product quality. In this way, they will not only be able to improve their performance but also increase their competitiveness relative to other countries [38].

For future research, it is suggested that a more in-depth analysis be conducted of the main destination markets for Peruvian citrus exports, prioritizing those with the largest market share and greatest commercial dynamism, in order to identify opportunities for expansion and consolidation. Likewise, it is advisable to incorporate additional variables such as logistics costs, phytosanitary requirements, and international trade trends in order to gain a more precise understanding of the factors affecting the sector's competitiveness.

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REFERENCES

- [1] ADEX. Asociación de Exportadores. El rol del Comercio internacional del Perú en su crecimiento económico 2024. [Internet]. 21 de diciembre de 2024. Disponible en: <https://adex.edu.pe/nota/comercio-internacional-peru-crecimiento-economico/#:~:text=El%20comercio%20internacional%20permite%20que,demanda%20en%20el%20mercado%20global>.
- [2] TRADE MAP. International Trade Centre (ITC). *Lista de los mercados importadores para un producto exportado por Perú. Producto: 080550 Limones "Citrus limón. Citrus limonum" y limas "Citrus aurantifolia, Citrus latifolia", frescos o secos.* [Internet]. 2025. Disponible en: https://www.trademap.org/Country_SelProductCountry_T_S.aspx?nvpm=3%7c604%7c%7c%7c%7c080550%7c%7c%7c6%7c1%7c1%7c2%7c2%7c1%7c2%7c5%7c1%7c1
- [3] Secretaría de Agricultura y Desarrollo Rural. Ratifica México su posición como segundo productor y exportador mundial de limones y limas. *Gobierno de México.* [Internet]. 11 de septiembre de 2024. Disponible en: <https://www.gob.mx/agricultura/prensa/ratifica-mexico-su-posicion-como-segundo-productor-y-exportador-mundial-de-limones-y-limas>
- [4] Rodríguez, D. Limón Tahití, el producto agrícola que está creciendo en exportaciones colombianas. [Internet]. Agronegocios. 15 de noviembre de 2024. Disponible en: <https://www.agronegocios.co/mercados/limon-tahiti-el-producto-agricola-que-esta-creciendo-en-exportaciones-colombianas-3999771>
- [5] FreshFruit. *Buen inicio del año para el limón Tahití fresco.* [Internet]. 16 de abril de 2023. Disponible en: <https://freshfruit.pe/2023/04/16/buen-inicio-del-ano-para-el-limon-tahiti-fresco/>
- [6] Portal Frutícola. *Limón Tahití peruano, una industria con proyección.* [Internet]. 28 de mayo de 2024. Disponible en: <https://www.portalfruticola.com/noticias/2024/05/28/limon-tahiti-peruano-una-industria-con-proyeccion/>
- [7] Ministerio de Desarrollo Agrario y Riego. *Situación del limón en Perú, un análisis económico* [Internet]. 2025.

- Disponible en: <https://cdn.www.gob.pe/uploads/document/file/7785163/6513789-situacion-del-limon-en-el-peru.pdf?v=1742230770>
- [8]Valdiviezo, R. *Reporte de Oportunidades no aprovechadas Febrero 2024 - Limón a Estados Unidos*. [Internet]. 28 de febrero de 2024. Disponible en: <https://cien.adexperu.org.pe/reporte-de-oportunidades-no-aprovechadas-febrero-2024-limon-a-estados-unidos/>
- [9]Cruz-López A, Caamal-Cauich I, Pat-Fernández VG, Ávila-Dorantes JA, Cruz-López DF. Competitividad y ventaja comparativa revelada de las exportaciones de aguacate Hass de México. *Remexca* [Internet]. 20 de marzo de 2025; 16(1): e3153. Disponible en: <https://cienciasagricolas.inifap.gob.mx/index.php/agricola/s/article/view/3153>
- [10]Martínez-Hernández A, Caamal-Cauich I, Pat-Fernández VG, Reza-Salgado J. Indicadores de competitividad de las exportaciones de mango mexicano en el mercado mundial. *Remexca* [Internet]. 9 de abril de 2025; 16(2): e3415. Disponible en: <https://cienciasagricolas.inifap.gob.mx/index.php/agricola/s/article/view/3415>
- [11]Del Fiori, D., Monteiro, T., Ramirez, Y., Soares, N., & Franco, S. Análise da competitividade brasileira no mercado mundial de limão e lima ácida e de seus principais competidores no mercado mundial. *Revista de Economia E Sociologia Rural* [Internet]. 1 de enero de 2025; 63. Disponible en: <https://doi.org/10.1590/1806-9479.2025.287274>
- [12]Ramírez-Padrón LC, Caamal-Cauich I, Pat-Fernández VG. Producción y competitividad del banano mexicano a nivel mundial. *Remexca* [Internet]. 9 de mayo de 2025; 16(3): e3626. Disponible en: <https://cienciasagricolas.inifap.gob.mx/index.php/agricola/s/article/view/3626>
- [13]Hernández, N., Gómez, A., Leos, J. & Loquez, C. Panorama de la Producción de Limones y su Exportación a la Unión Europea. *Academia Journal*. [Internet]. 2023; 15(5). Disponible en: https://www.researchgate.net/publication/371787058_Panorama_de_la_Prod
- [14]Hernández-Mendoza N, Luquez-Gaitan CE, Ireta-Paredes A del R. Análisis de la ventaja comparativa revelada normalizada del jitomate mexicano exportado a Estados Unidos, 1994-2020. *Estudios Sociales* [Internet]. 22 de septiembre de 2023; 33(62). Disponible en: <https://www.ciad.mx/estudiosociales/index.php/es/article/view/1353>
- [15]Rivera, C. Competitiveness of the Mexican coffee in international trade: a comparative analysis with Brazil, Colombia, and Peru (2000 -2019). *Análisis Económico* [Internet]. 6 de enero de 2022;37(94):181-99. Disponible en: <https://doi.org/10.24275/uam/azc/dcs/ae/2022v37n94/rivera>
- [16]Rinconada, F., García, F., & Serna Hinojosa, J. Specialization and Comparative Advantage of the Citrus Sector in Mexico: 1990-2018. *Economía Teoría y Práctica* [Internet]. 2022; (56):155-74. Disponible en: <https://doi.org/10.24275/etypuam/ne/562022/rinconada>
- [17]Ovalle, A., & Ramírez, E. Sobre la ventaja comparativa revelada de los productos agroindustriales del departamento del Huila. *Erasmus semilleros investig.* [Internet]. 8 de febrero de 2021; (Extra):36-44. Disponible en: <https://journalusco.edu.co/index.php/erasmus/article/view/3439>
- [18]Aroquipa, O., & Meza, M. MEDICIÓN DE LA COMPETITIVIDAD DE LAS EXPORTACIONES DE PALTA y UVAS CON EL ÍNDICE DE VENTAJA COMPARATIVA REVELADA; PARA LA REGIÓN DE AREQUIPA, PERÚ 2010-2019*. *Veritas* [Internet]. 25 de abril de 2022; 22(2):31. Disponible en: <http://doi.org/10.35286/veritas.v22i2.308>
- [19]Stellian, R., & Danna, J. ¿Qué indicador de ventaja comparativa revelada escoger? Consideraciones teóricas y empíricas. *Revista Cepal*. [Internet]. 2022; 138(50-71). <https://repositorio.cepal.org/server/api/core/bitstreams/b6709843-f9a4-4665-9f9f-e7ddb35bd3fd/content>
- [20]Cruz, D., Caamal, I., & Pat, V. (2024). Applying the Vollrath and Lafay indicators to measure the competitiveness of mexican avocado. *ASYD* [Internet]. 2024 Sep. 27; 21(4):490-504. Available from: <https://www.revista-asyd.org/index.php/asyd/article/view/1644>
- [21]Nel, P., Guillermo, W., & Danna, J. LAS TEORÍAS DE LA COMPETITIVIDAD: UNA SÍNTESI. *Revista Republicana* [Internet]. 31 de julio de 2021; 31:119-44. Disponible en: <https://doi.org/10.21017/rev.repub.2021.v31.a110>
- [22]Rosenfeld, T., Mota, I., & Pereira, E. International Trade and Income Inequality: The Case of Latin American Countries. *The International Trade Journal* [Internet]. 18 de abril de 2024; 38(5):469-89. Disponible en: <https://doi.org/10.1080/08853908.2024.2341624>
- [23]Ikechukwu, I., Fyeface, P., & Anochie, C. ASSESSING THE CONCEPT OF HECKSCHER OHLIN MODEL. *bj* [Internet]. 2022 Oct. 26; 1(1):7. Available from: <https://mail.bwjjournal.org/index.php/bsjournal/article/view/956>
- [24]Sempere, J. ¿Ha fracasado la teoría del libre comercio? Una revisión crítica de la teoría de los tratados comerciales. *FI* [Internet]. 29 de junio de 2022; 62(3):609-37. Disponible en: <https://forointernacional.colmex.mx/index.php/fi/article/view/2633>
- [25]Valencia, C. Heterogeneidad de las firmas en el comercio internacional: un mapeo sistemático de la literatura. *estud.gerenc.* [Internet]. 2025 Feb. 28; 40(173):394-405. Available from: https://www2.icesi.edu.co/revistas/index.php/estudios_gerenciales/article/view/6908
- [26]OECD/ Eurostat. *Oslo Manual 2018: Guidelines for Collecting, Reporting and Using Data on Innovation*, 4th Edition, The Measurement of Scientific, Technological and Innovation Activities, OECD publishing, Paris/Eurostat, Luxembourg. [Internet]. 2018. Disponible en: <https://doi.org/10.1787/9789264304604-en>
- [27]Godwin, A., Benedict, B., Rohde, J., Thielmeyer, A., Perkins, H., Major, J., Clements, H., & Chen Z. Nuevas

perspectivas epistemológicas sobre métodos cuantitativos: Un ejemplo con análisis topológico de datos. *Estudios en Educación en Ingeniería*. 2021;2(1):16–34.

[28]Calle, S. (2023). Diseños de investigación cualitativa y cuantitativa. *Ciencia Latina* [Internet]. 31 de julio de 2023; 7(4):1865-79. Disponible en: <https://ciencialatina.org/index.php/cienciala/article/view/7016>

[29]Corona, L., y Fonseca, M. ¿Mi estudio es transversal o longitudinal? *Medisur* [Internet]. Agosto de 2023; 21(4): 931-934. Disponible en: http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S1727-897X2023000400931&lng=es.

[30]Guevara, G., Verdesoto, A., & Castro, N. Metodologías de investigación educativa (descriptivas, experimentales, participativas, y de investigación-acción). *RECIMUNDO* [Internet]. 16 de julio de; 4(3):163-7. Disponible en: <https://www.recimundo.com/index.php/es/article/view/860>

[31]Yllescas, P., Espinoza, R., & Macha, R. Diversificación de la oferta exportable y las exportaciones peruanas. *Koinonia* [Internet]. 1 de diciembre de 2021; 6(1):322-41. Disponible en: <https://fundacionkoinonia.com.ve/ojs/index.php/revistakoinonia/article/view/1510>

[32]Chero, V. (2024). Population and sample. *Int. j interdiscip. dent.* [Internet]. 2024 Aug; 17(2): 66-66. Available from: http://www.scielo.cl/scielo.php?script=sci_arttext&pid=S2452-55882024000200066&lng=en. <http://dx.doi.org/10.4067/s2452-55882024000200066>.

[33]Medina, M., Rojas, R., Bustamante, W., Loaiza, R., Martel, C. & Castillo, R. Metodología de la investigación: Técnicas e instrumentos de investigación. *INUDI*. [Internet].2023. Disponible en: <https://editorial.inudi.edu.pe/index.php/editorialinudi/catalog/view/90/133/157>

[34]González, R. & Santiago, Y. El método hipotético deductivo de Karl Popper en los estudiantes de la Educación Básica Regular en Perú. *Educación* [Internet]. 5 de julio de 2023;29(2):1-15. Disponible en: <https://doi.org/10.33539/educacion.2023.v29n2.3045>

[35]Rosas, M. & Villasana, P. Adopción de tecnologías en sistemas de producción agroalimentario: una revisión de literatura. *Sociedad* (University Of Buenos Aires) [Internet]. 20 de junio de 2022; Disponible en: http://www.scielo.cl/scielo.php?script=sci_arttext&pid=S0719-49942022000200177

[36]Ruiz, S. Estrategias de Gestión de la Cadena de Suministro en un Mundo Globalizado. *RCZ* [Internet]. 2024 May 31; 3(2):97-119. Available from: <https://revistaczambos.utelvtsd.edu.ec/index.php/home/article/view/19>

[37]Martínez, G. El impacto de la logística en la facilitación del comercio internacional: un estudio de costos y beneficios. *epsir* [Internet]. 20 de febrero de 2025; 10:1-10. Disponible en: <https://epsir.net/index.php/epsir/article/view/1626>

[38]Limas, S., Poveda, D., & Cifuentes, J. La competitividad de Colombia frente a los países de América Latina 2010-2021: avances y desafíos. *Revista Universidad y Empresa* [Internet]. 22 de marzo de 2024;26(46):1-33. Disponible en: <https://doi.org/10.12804/revistas.urosario.edu.co/empr esa/a.13653>