Colegio de Postgraduados

Determinants of the mean rural price of Maradol papaya (*Carica papaya* L.)

Ríos-Avendaño, Milka J.[1]**; Vega-Valdivia, Dixia V.**[1*]**; Pérez-Zamorano, Abel, N.**[1]

[1] Universidad Autónoma Chapingo, Carretera Federal México-Texcoco Km 38.5, C. P. 56230 Texcoco, México.

* Correspondence dixiadania@gmail.com

ABSTRACT

Objective: To analyze the factors influencing the low Farm Gate Price (FGP) faced by Maradol papaya producers in Villa de Tututepec, Oaxaca, a municipality that accounts for 40.9% of the state's production and 11.5% of the national production, yet whose FGP is 20.7% lower than the national average, ranking 167th among the 229 papaya-producing municipalities distributed across 19 states in Mexico.

Design/methodology/approach: A total of 155 commercialization units were georeferenced, and their effects on the FGP were analyzed using cartography in QGIS, distance measurement, and a bubble chart in Python that related FGP, production volume, infrastructure, and state-level competition.

Results: Limited commercialization infrastructure and long distances to major markets reduce the FGP received by producers. Although greater infrastructure availability can improve sales conditions, its effect may be moderated by high local competition. Furthermore, a high production volume, without adequate logistical support, tends to saturate the market and exert additional downward pressure on prices.

Limitations on study/implications: The lack of specific data on transportation conditions limited the construction of a more robust econometric model and reduced the significance of the variables analyzed.

Findings/conclusions: Strengthening logistical infrastructure and improving proximity to distribution channels could significantly increase the income of Maradol papaya producers in Villa de Tututepec.

Keywords: Farm Gate Price (FGP), commercialization infrastructure, logistical accessibility, geographic information systems (GIS).

Citation: Ríos-Avendaño, M. J., Vega-Valdivia, D. V., &Pérez-Zamorano, A. N. (2025). Determinants of the mean rural price of Maradol papaya (*Carica papaya* L.). *Agro Productividad*. https://doi.org/10.32854/718mp246

Academic Editor: Jorge Cadena Iñiguez
Associate Editor: Dra. Lucero del Mar Ruiz Posadas
Guest Editor: Juan Francisco Aguirre Medina

Received: April 29, 2025.
Accepted: November 30, 2025.
Published on-line: January XX, 2026.

Agro Productividad, 18(12). December. 2025. pp: 87-95.

INTRODUCTION

For farmers, the price received for their production constitutes virtually the only determinant of their agricultural income (Timmer, 1983). In this sense, the Farm Gate Price (FGP) constitutes a key measure to evaluate the primary profitability of crops. In addition, it allows identifying structural faults in the market, such as insufficient infrastructure, high transport costs, or intermediation problems, factors that can distort the prices paid to the producer. In the case of perishable products, the FGP acquires special relevance, since it determines the income that producers obtain before the product loses value due to its fast decomposition. In this context, Maradol papaya (*Carica papaya* L.) is especially vulnerable

due to its short post-harvest life and the need for efficient logistical management to preserve its quality and value.

Mexico occupies an outstanding place in the global agricultural economy. According to recent data, in 2023, it was consolidated as the ninth largest global exporter of agrifood products (Morales, 2024) and the twelfth in terms of total agricultural production (SENASICA, 2016). In this context, Maradol papaya stands out as a crop of strategic importance, not only because of its production volume, but also for its role in foreign export. According to data from FAOSTAT (2024), Mexico is the third global producer of papaya, but it leads world exports of this fruit, which evidences a high exporting efficiency. Within the segment of "Edible fruits", papaya occupies the thirteenth place in value of national exports, according to the International Trade Center (ITC, 2024), with the Maradol variety being the most representative in the country.

Based on data consulted in SIACON (SIAP, 2024), Oaxaca led Maradol papaya production in Mexico in 2023, with 318,322.7 tons, equivalent to 28% of the total national production. Villa de Tututepec de Melchor Ocampo concentrated 40.9% of the state production and 11.5% of the national production, positioning itself as the main producing municipality in the country from among 229 municipalities. However, the FGP in Villa de Tututepec was $5,558.35 pesos MX per ton, 20.7% lower than the national average of $7,013.11 pesos MX, which shows a contradiction between the high production volume and the low price, attributable to structural factors that affect the income of local producers. Given this panorama, it is essential to analyze statistically and geographically the conditions of Maradol papaya producing municipalities, to identify the factors that explain the differences in farm gate prices. Understanding these elements will allow proposing strategies to improve the profitability of producers and to consolidate the exporting leadership of Mexico in this crop.

MATERIALS AND METHODS

The study was conducted under a quantitative, descriptive and comparative approach, with the objective of identifying the factors that impact the low levels of farm gate prices (FGPs) in the municipalities where Maradol papaya is produced, with special emphasis on the case of Villa de Tututepec, Oaxaca. To achieve this purpose, statistical and geographic analysis tools were applied, using primary and secondary information.

The database was built from records of the Agrifood and Fishing Information Service (*Servicio de Información Agroalimentaria y Pesquera*, SIAP) from 2023, which provided information about the production (ton) and the FGP ($/ton) of 229 producing municipalities distributed in 19 states of Mexico. Box diagrams were elaborated with these data to analyze the dispersion of the FGP, and dispersion graphs to explore their relationship with the production volume.

In addition, a bubble and dispersion graph was elaborated using Python code executed in Google Colab, with the objective of examining the interaction between FGP, production volume, commercial infrastructure (measured as the sum of packaging units and main supply centers in each state), and state competition (defined as the percentage of producing municipalities compared to the total of municipalities in each state).

To delve into the analysis of commercial infrastructure and its relationship with logistical distances, 155 packaging units and supply centers in the country were identified, using official sources such as the Directory of Certified Suppliers from SENASICA, the National Directory of Exporters from the Ministry of Agriculture, the Directory of Supply Centers from the Ministry of Economy, as well as complementary searches in Google Maps and social networks. Each packaging unit and supply center was georeferenced, which, in combination with the data of state FGP, allowed elaborating a map in QGIS software that represented the location of commercial infrastructure and its spatial relationship with the levels of FGP of each producing state. This representation facilitated the identification of zones with logistics advantages, access gaps to infrastructure, and strategic zones for the commercialization of Maradol papaya. Likewise, geopositioning data of the packaging and distribution centers, together with a representative sample of 38 municipalities (two for each state: the one with the highest and the one with the lowest FGP), were used to calculate the distances from each packaging unit and/or commercial center towards the producing municipalities of the sample. Then, the average of the distances corresponding to each municipality was obtained, thus generating the variable "average distance to local infrastructure".

Additionally, considering that wholesalers from Mexico City's Supply Center (CEDA-CDMX) tend to assume the transport costs, according to interviews conducted with producers from Villa de Tututepec, the distances from each municipality of the sample to the CEDA-CDMX were also measured. Both measurements of distance were later compared with the respective averages of municipal FGPs, with the aim of analyzing their possible effect on the producer's price.

RESULTS AND DISCUSSION

Despite its leadership in production volume, Villa de Tututepec presents a considerably low FGP compared to the 229 Maradol papaya producing municipalities in Mexico. This contradiction is evidenced in the box diagram, where the inter-quartile range of the FGP is found between $5,478.5 and $7,300 pesos MX, covering 50% of the municipalities. The median, of $6,619.23 pesos MX, confirms that Villa de Tututepec is among the municipalities with lower FGP than this value.

The extreme values of the diagram correspond to the highest and lowest FGPs recorded in Altamira, Tamaulipas ($12,540.88) and Mocorito, Sinaloa ($3,045.00), respectively. Villa de Tututepec, with a FGP of $5,558.35, is below the national average ($7,011.51) and slightly over the first quartile, within the second quartile of municipalities with the lowest prices.

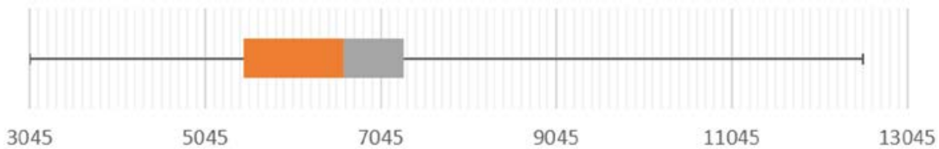

Figure 1. Variability of the Maradol papaya in municipalities of Mexico.

Analyzing the factors that impact the differences in FGP between the municipalities is essential. In the first place, it is suggested that a higher production volume could pressure the prices to decrease. The dispersion graph shows that the municipalities with lower production tend to obtain higher prices, while those with higher offer show lower FGPs. Although Villa de Tututepec is the principal producer, it presents a lower FGP than the national average, which evidences that a high volume does not ensure better commercial conditions.

The inverse relationship between the offer and the FGP indicates that a higher production volume does not always imply better prices for the producer. However, reducing the productive volumes would not be an adequate strategy, because these high volumes are derived mainly from the high crop yields in the region, which reached 107.24 ton/ha in 2023, figure 102.7% higher than the national mean (52.9 ton/ha). This outstanding yield reflects the high agricultural potential of the zone, previously identified by Espinosa Trujillo *et al.* (2018), who emphasized that the climate conditions in Oaxaca offer a better productive potential (14.6%) for papaya in comparison to states like Campeche (9.8%), Michoacán (5.6%) or Colima (0.4%), which suggests the intervention of other structural factors in the determination of the price.

When the average state FGP was considered as the representative indicator of the prices received by the municipalities within the local market, and when analyzing their relationship with their respective variables of commercial infrastructure, production volume, and market competition, a broader panorama about the formation of farm gate prices is revealed. Although the individual analysis of each variable shows low correlations, their joint interaction gives a better understanding of the factors that impact the behavior of the FGP.

In the bubble graph, Oaxaca is found in the lower left corner, with a Farm Gate Price (FGP) of approximately \$6,056/ton, reflecting high production volumes, but minimal commercial infrastructure, which limits its capacity for negotiation and reduces the price received. Colima is found towards the middle right part of the graph, with a FGP of \$7,721/ton, characterized by a very high commercial infrastructure (60 units), but affected by high competition between municipalities, which decreases the positive impact of said infrastructure in the prices. On the other hand, in the upper left part, Tamaulipas and the State of Mexico stand out, with FGPs of \$12,112/ton and \$8,914/ton, respectively, where the highest prices are found despite their low levels of production, competition and infrastructure. These patterns show that, in addition to productive and commercial factors,

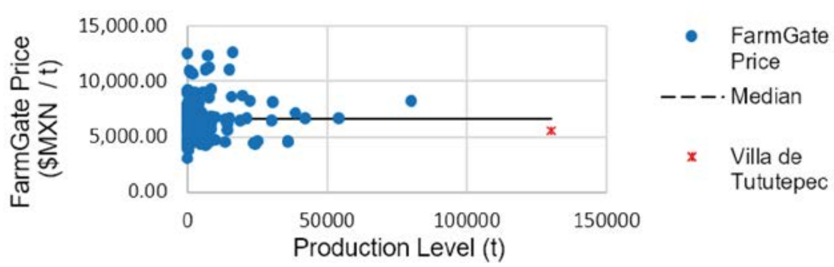

Figure 2. Relationship between the Maradol papaya offer and the FGP per municipality.

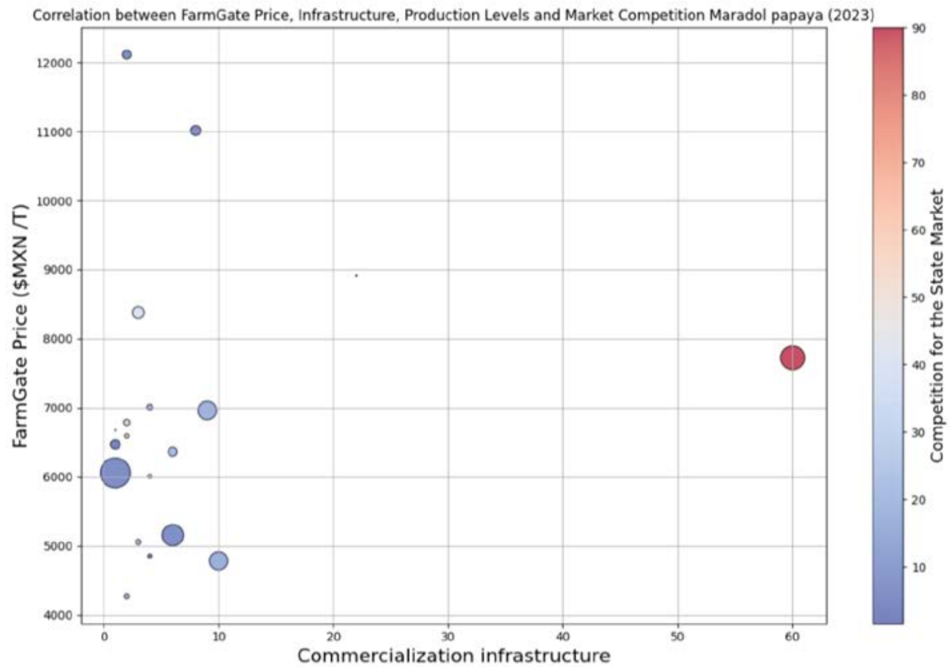

Figure 3. Relationship between FGP, infrastructure, production and state competition for Maradol papaya (2023).

the geographic location and proximity to strategic markets carry out a defining role in the formation of the farm gate price of Maradol papaya. In this context, the importance of spatially locating each state according to its distribution of FGP and commercial infrastructure emerges, as is presented in the following map.

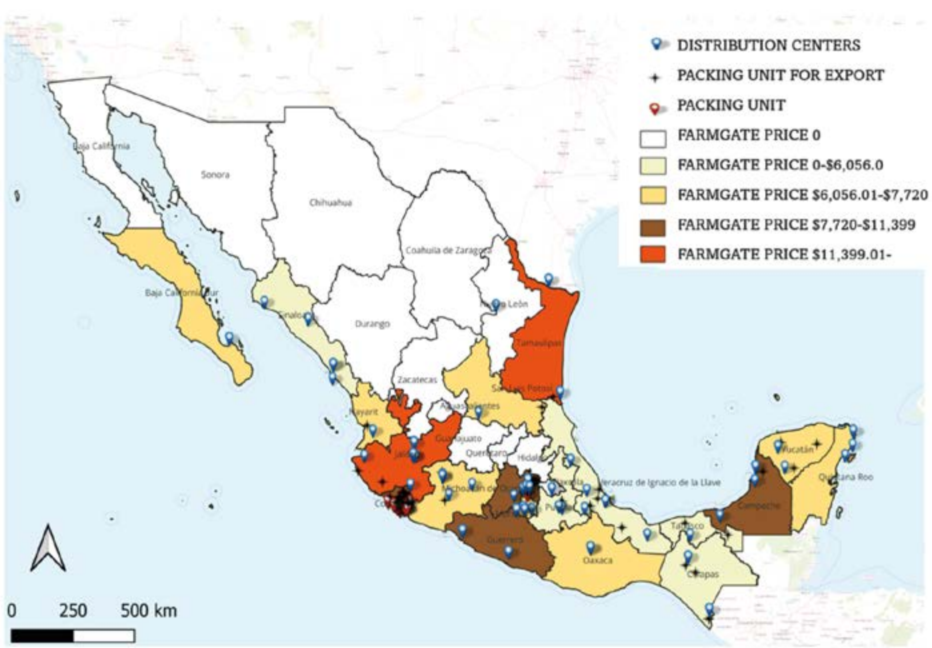

Figure 4. Relationship between commercial infrastructure and papaya FGP in Mexico.

Table 1. Relationship between the average FGP and the distance to commercial centers.

Distance Type	Range	Interval (km)	Average Farmgate Price ($MXN/ t)
Local infrastructure	Short	0-190	7,105.10
	Medium	190-380	6,976.80
	Long	>380	6,949.4
CEDA-CDMX[1]	Short	0-600	7,209.01
	Medium	600-1200	7,055.01
	Long	>1200	6,305.50

[1] CEDA-CDMX=Mexico City Central Wholesale Market.

The map reaffirms that Tamaulipas and State of Mexico achieve the highest FGPs despite their limited infrastructure, production and competition, thanks to their strategic location. Tamaulipas, with only four commercialization units, benefits from its proximity to the United States, which in 2023 absorbed 99.9% of the Mexican exports of papaya (ITC, 2024). Similarly, the State of Mexico, with high population concentration and located in the area of influence of the CEDA-CDMX, the largest wholesale market in the world (CCA, 2021), attains high prices despite its low production, supported by its reliance on external supply, dynamic that also benefits highly producing and neighboring states, such as Colima.

These geographic patterns confirm that, although the infrastructure does not determine by itself the price to the producer, its availability and strategic location can favor better commercial conditions. To delve into this relationship, a group of 38 producing municipalities was analyzed, which were selected for their extreme prices (two per each producing state), where a negative correlation between the distance to local infrastructure or to the CEDA-CDMX and the Farm Gate Price (FGP) was evidenced, highlighting the key role of the territorial component in the formation of agricultural prices.

The table shows that the producing municipalities located at less than 190 km from the local infrastructure or at less than 600 km from the CEDA-CDMX show the highest FGPs, of more than $7,000/ton. In contrast, those located at a distance of more than 1,200 km present decrease by up to 10% compared to the national average, confirming that the proximity to stockpiling and distribution centers favors better prices for the producer. Although in Villa de Tututepec producers do not assume the total cost of transportation directly, the distance impacts the price received, since the buyers adjust the value offered to compensate for the logistical expenses, estimated in 30 pesos per kilometer in 2023 according to interviews with local producers.

This pattern responds not only to the increase in the transport costs associated with longer distances, but also to the participation of more intermediaries in the national chain. Granados Ramírez *et al.* (2015) document a similar phenomenon in Veracruz, where the lack of logistical infrastructure transfers the transport and storage of papaya to the entrepreneurial sector, favoring higher margins of profit for the intermediaries. In Villa de Tututepec, a comparable dynamic is observed: the buyers, in addition to adjusting the price by distance, apply discounts from physical damage to the fruit during transport, reducing even more the producer's income. Although the distances vary, the CEDA-DCMX is the main sales destination in both cases: Veracruz is located at around 380 km (six hours away) and Villa de Tututepec at 727 km (10.5 hours), which reinforces the idea that the distance and the lack of local infrastructure increase reliance on intermediaries and reduce the profitability of the producer.

Pindyck and Rubinfeld (1998) suggest taking advantage of economies of scope (ES) in transport, reducing costs when combining loads of different products with the same destination. This strategy could be viable in Villa de Tututepec, where the producers, in addition to Maradol papaya, grow lime, watermelon, corn, coconut, banana and mango, which increases the potential to consolidate mixed shipments towards CEDA-CDMX.

To measure the economy of scope (ES) in transport, the cost of sending two products separately is compared with the cost of transporting them together. If the joint cost is lower, there is an advantage in logistical, operative or infrastructure efficiency (Pindyck and Rubinfeld, 1998). The ES is calculated as:

$$ES = \left(C\left(q_1\right) + C\left(q_2\right) - C\left(q_1, q_2\right)\right) / C\left(q_1, q_2\right)$$

where: $C\left(q_1\right)$ and $C\left(q_2\right)$ are the individual costs of transport, and $C\left(q_1, q_2\right)$ the combined cost.

In Villa de Tututepec there are structural limitations to achieve economies of scope, since papaya, transported in bulk and with minimum packaging, is vulnerable to damage and requires conservation temperatures between 10 and 13 °C (Shakila and Anburani, 2010). This makes its logistical compatibility with other local crops such as lime or watermelon difficult, which demand lower temperatures (5-10 °C) and use refrigerated transport in boxes or sacks (AgroMarket, 2003).

Although papaya can be transported together with compatible crops such as mango (AgroMarket, 2003), interviews with producers and transporters indicate that the cost of the freight towards CEDA-CDMX or Puebla is the same for both products ($22,000 per shipment). Therefore, when the formula for economy of scope is applied, the result is zero, which reflects absence of logistical savings when combining them.

However, specific conditions are identified where a positive economy of scope could be generated in transport. According to local testimonies, in 2023, the cost of sending a Torton-type truck —three-axle, with approximate size of 6.50×2.50×2.40 meters (FAW México, s.f.)— was $22,000, regardless of the volume of the loads shipped and who pays for it, although 13 and 16 tons were considered the standard capacity of the truck and the minimum volume that transporters and stockholders require for the shipment payment to be convenient. Although these trucks can withstand up to 20 tons (FAW Mexico, s.f.), when exceeding 16 tons, the transporter applies an additional charge of $1,000 for each extra ton. Given that some papaya harvests do not always reach the 13 tons required, completing the load with compatible products such as mango would allow taking better advantage of the capacity available. In a scenario of combined load —13 tons of papaya and 7 of another fruit—, the total cost of transporting both products in a joint manner would reach $29,000, while conducting two separate shipments it would cost \$44,000. The economy of scope (ES) is assessed as:

$$ES = \left(\left(\$22{,}000 + 22{,}000\right) - \$29{,}000\right) / \$29{,}000 = 0.517 = 51.7\%$$

of savings, which shows a significant improvement in the logistical efficiency under controlled conditions.

If the cost of \$29,000 were assumed by an alliance of producers, the unitary transport from Tututepec to CEDA-CDMX would be approximately \$1,450 per ton. This would allow them to trade their papaya at similar prices to those found in the State of Mexico, where in 2023 the farm gate price was \$8,914.30 per ton. In comparison, Villa de Tututepec received \$5,558.35, reflecting a loss of \$3,355.95 per ton when the stockpiler pays for the shipment. Thus, even when paying for transport, producers could significantly improve their income, representing a profitable opportunity.

Nevertheless, this strategy implies logistical and sanitary risks. According to FAO and WHO (2005), joint transport, even between compatible producers, can cause cross-contamination, physical damage, acceleration of maturation from exposure to ethylene, and even total rejection of the load when there is deterioration. In addition, it could complicate the unloading and classification, increasing time and operative costs.

Despite the challenges, sharing transport units continues to be viable in Villa de Tututepec, not only because most of the producers handle surfaces of 3 to 5 hectares in the same scale of production, which allows them to reach considerable volumes, but also because they can become consolidated with other producers from the same municipality to form joint loads. This highlights the need to improve packaging, going from bulk shipping to more streamlined systems that, in addition to protecting the quality of the fruit, reduce damage during transport. Likewise, it is essential to establish local packaging centers that decrease the reliance on external infrastructure. These actions would not only improve the price for producers but would also open access to markets of higher value, including direct exports currently limited by logistical and commercial presentation deficiencies.

CONCLUSIONS

The low Farm Gate Price (FGP) of Maradol papaya producers in Villa de Tututepec is the result of structural factors that limit their commercialization, among them the scarce infrastructure for packaging and distribution, the distance from main supply centers, and local competition. Although the municipality presents high productive yields, the lack of adequate logistics restricts its competitiveness. The results emphasize that improving packaging, establishing stockpiling centers, and optimizing transport through consolidated loads are key strategies to strengthen the commercial position, reduce damage, and gain access to markets of higher value. The conclusion is that logistical restructuring is essential to increase the income of producers and to consolidate their competitiveness in the Maradol papaya market.

ACKNOWLEDGEMENTS

The authors wish to thank the papaya producers from the municipality of Villa de Tututepec, Oaxaca, for their willingness to share information that made it possible to conduct the study. We also recognize the valuable support of warehouse keepers and representatives of auto-transport companies that participated in telephone surveys about the dynamics and costs of transport for Maradol papaya. We especially thank the academic body and the advising committee of the corresponding educational institution, whose methodological guidance and critical revision improved the quality of this manuscript.

REFERENCES

1. Timmer, C. P. (1983). Food policy analysis. Published for the World Bank by The Johns Hopkins University Press. https://archive.org/details/foodpolicyanalys0000timm/page/10/mode/2up
2. Morales, R. (2024, marzo 19). México escaló a la 9° posición entre los mayores exportadores. El Economista. https://www.eleconomista.com.mx/empresas/Mexico-escalo-a-la-9-posicion-entre-los-mayores-exportadores-20240319-0148.html
3. Servicio Nacional de Sanidad, Inocuidad y Calidad Agroalimentaria (SENASICA). (2016, diciembre 9). México es el 12º productor mundial de alimentos. Gobierno de México. https://www.gob.mx/senasica/articulos/mexico-es-el-12-productor-mundial-de-alimentos-86710
4. Food and Agriculture Organization of the United Nations (FAO). (2024). FAOSTAT. Statistics Database. https://www.fao.org/faostat/es/#data
5. International Trade Center (ITC). (2024). Trade Map: Statistics for international business development. https://www.trademap.org/Index.aspx
6. Servicio de Información Agroalimentaria y Pesquera (SIAP). (2024). SIACON: Sistema de Información Agroalimentaria de Consulta. https://www.gob.mx/siap/documentos/siacon-ng
7. Comisión para la Cooperación Ambiental (CCA). (2021). Central de Abasto de la Ciudad de México (CEDA): Comprensión de la pérdida y el desperdicio de alimentos en el mercado más grande del mundo. https://www.cec.org/files/documents/publications/ceda_es.pdf
8. Granados Ramírez, R., Salceda López, R., & del Pilar Longar Blanco, M. (2015). Situación actual y perspectivas tecnológicas para la papaya (*Carica papaya* L.) en el distrito de Veracruz, Veracruz. *Revista Mexicana de Ciencias Agrícolas, 6*(4), 749-761. https://www.scielo.org.mx/pdf/remexca/v6n4/v6n4a7.pdf
9. Pindyck, R. S., & Rubinfeld, D. L. (1998). Microeconomía (4ª ed.) [Archivo PDF]. Prentice Hall. https://danielmorochoruiz.wordpress.com/wp-content/uploads/2017/01/microeconomia_-_pyndick.pdf
10. Shakila, A., & Anburani, A. (2010). Effect of storage temperatures on the quality and shelf life of papaya. *Acta Horticulturae*, 851, 537–540. https://doi.org/10.17660/ActaHortic.2010.851.82
11. AgroMarket. (2003, enero 25). Guía de temperaturas para el almacenamiento de algunas frutas. https://agro-market.com.mx/guia-de-temperaturaspara-el-almacenamiento-de-algunas-frutas/
12. FAW México. (s.f.). Clasificación de camiones de carga. https://faw.mx/index.php/noticias/clasificacion-de-camiones-de-carga
13. Organización de las Naciones Unidas para la Alimentación y la Agricultura (FAO), & Organización Mundial de la Salud (OMS). (2005). Código de prácticas de higiene para el transporte de alimentos a granel y alimentos semienvasados. http://innocua.net/web/download-1630/cxp-047s.pdf