Colegio de Postgraduados

Feasibility study of pitahaya (*Hylocereus undatus* (Haworth) D.R. Hunt) production in the Mixteca Poblana region

Pérez-Rosales, Alejandro[1]; Ayala-Garay, Alma V.[1,2*]; Silva-Barranco, Javier[1]; Arias-Aragón, Adalit[3]; Estévez-Martínez, Yoxkin[1]

[1] Instituto Tecnológico Superior de Acatlán de Osorio, Carretera Acatlán - San Juan Ixcaquistla km 5.5, Del Maestro, Unidad Tecnológica Acatlán, Acatlán, Puebla, C. P. 74949.
[2] Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias, Campo Experimental Valle de México, Carretera los Reyes-Texcoco km 13.5, Coatlinchán Texcoco, Estado de México, C. P. 56250.
[3] Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias, Campo Experimental Zacatepec, Km. 0.5 Carretera Zacatepec, Galeana - Cuautla S/N, Centro, 62780 Zacatepec, Mor.
* Correspondence: ayala.alma@inifap.gob.mx

ABSTRACT

Objective: To conduct a pitahaya production feasibility analysis in Tepexi de Rodríguez, Mixteca Poblana region, Puebla.

Design/Methodology/Approach: Twenty local producers were subjected to a panel technique. The research took place from May to June, 2023. The results were used to determine main economic indicators such as internal rate of return (IRR), net present value (NPV), and benefit-cost ratio (BCR).

Results: The plantation was established less than 6 years ago. Pitahaya cultivation is profitable. The NPV was >0 (MXN$302,361.58), while the IRR recorded 28.29% —a percentage higher than the discount rate. Meanwhile, the BCR reached 1.35: for every MXN$ invested, a profit of MNX$0.35 was obtained.

Study Limitations/Implications: The lack of customers that guarantee the purchase of the fruit before or during the harvest is a limiting factor.

Findings/Conclusions: Finding commercialization channels and transformation processes for specific markets is very important. In addition, increasing the demand and improving the commercial positioning of pitahaya is fundamental. Pitahaya can be grown in different areas and its consumption benefits make it a feasible and profitable crop.

Keywords: Production costs, income, financial indicators.

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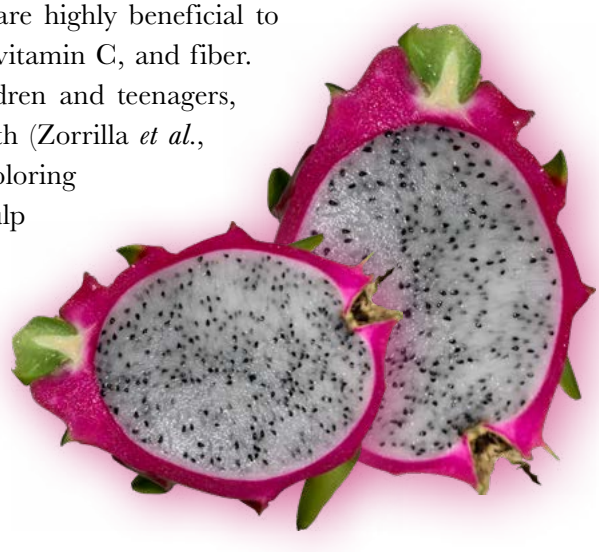
INTRODUCTION

Pitahaya (*Hylocereus undatus* (Haworth) D.R. Hunt) has abundant nutritional and medicinal properties that are highly beneficial to humans, including phosphorous, calcium, vitamin C, and fiber. Its consumption is recommended for children and teenagers, because it strengthens their bones and teeth (Zorrilla *et al.*, 2004). In addition, pitahaya is a natural coloring agent: the intense colors of its skin and pulp are a result of its betacyanin content (Tze *et al.*, 2012). Pitahaya fruits are highly demanded in both domestic and international markets (García and Quirós, 2010). The adaptability of



pitahaya plants to harsh weather conditions makes them an option to replace traditional crops in marginal areas. Currently, this plant grows in the wild in 20 states of Mexico. However, it is grown as a commercial crop in some regions of the country. Pitahaya is an exotic fruit with a sweet taste and high-water content (Ortega *et al.*, 2018).

From 2010 to 2021, pitahaya was produced in the Mexican states of Yucatán, Tabasco, Sinaloa, Quintana Roo, Puebla, Nayarit, Jalisco, Guerrero, Guanajuato, and Aguascalientes. However, Quintana Roo and Yucatán produced approximately 92.4% of the total domestic production (SADER-SIAP, 2023).

The state of Puebla accounted for 6.12% of the domestic production during the same period, reaching a volume of 595.6 t and an average profit of 4.68 t/ha. In 2022, pitahaya was produced in the irrigation districts of Izúcar de Matamoros, Tecamachalco, and Tehuacán, accounting for 4.6, 45.7, and 49.7% of the state production, respectively (SADER-SIAP, 2023). This plant grows under semiarid conditions and, therefore, the extreme weather of the Baja Mixteca Poblana is ideal for its production.

Other studies have proved that growing pitahaya in Mexico is feasible. Michel *et al.* (2022) pointed out that its direct sale in Jalisco has a 2.66 BCR —*i.e.*, pitahaya is profitable and its profitability could be even greater without middlemen. Meanwhile, Ayala *et al.* (2023) indicated that pitahaya is a promising crop for producers, because it is profitable and does not require a high investment once the plant starts to grow, as long as the producer finds a buyer. Finally, Aguilar *et al.* (2017) also mentioned that pitahaya can be successfully grown and that it can reach a very favorable price abroad. In addition, it becomes profitable between the third and fourth year of production.

Therefore, the objective of this research was to conduct a pitahaya production economic feasibility study in the Mixteca Poblana region, particularly in the municipality of Tepexi de Rodríguez, Puebla. In addition, the characteristics of the producers and the production units were established.

Pitahaya is a profitable fruit in the area, has market potential, and can improve the wellbeing of the producers.

MATERIALS AND METHODS

Location

Tepexi de Rodríguez is one of the municipalities of the Mixteca Poblana. It is located in southern Puebla, at 18° 20' 24" and 18° 37' 42" N and at 97° 46' 00" and 98° 03' 18" W (INEGI, 2014). The altitude of the region ranges from 1,200 to 1,700 m.a.s.l. (Mindek, 2003). The area is divided into two regions with distinct climates: subhumid with summer rains (65.05%) and subhumid temperate with summer rains (34.95%). As a whole, the region has warm summer and temperate winters (Figure 1) (INEGI, 2010).

The soils of the Mixteca are basic, with a 6.8-8.7 pH (Altieri *et al.*, 2006). Leptosols cover approximately 65.42% of the region (INEGI, 2010). These soils are shallow and stony, with rocks in all or very close to the surface. These soils can be found in all types of weather (dry, temperate, humid) and are particularly common in mountain areas and shallow limestone plains. Their calcium content can immobilize minerals. In addition, their scarce depth and

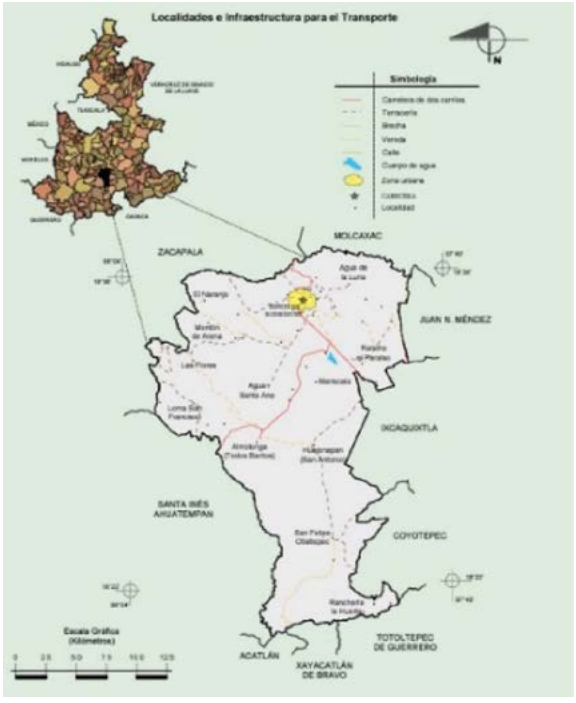


Figure 1. Study area of pitahaya (*Hylocereus undatus* (Haworth) D.R. Hunt) in Tepexi de Rodríguez, Puebla, Mexico. Source: INEGI, 2010.

high stone content limit agricultural practices and they require appropriate techniques to grow crops (IUSS Grupo de Trabajo WRB, 2007).

Agriculture is the main economic activity of the municipality and employs half of the active population of the area. The second most important economic activity is exploitation and exportation of marble, extracted from different local mines (Gobierno del Estado de Puebla, 2014).

Surveys

A direct survey was designed and applied based on Rojas (2022), who pointed out that this type of survey is appropriate when there is not enough data about the aspects to be researched or when the information cannot be obtained using other techniques. The survey included subjects related to the producer characteristics, production systems, economic feasibility, and commercialization of pitahaya in the region.

Producer panels

Data was obtained applying the survey to producer panels. The panel data methodology [Red Mexicana de Investigación en Política Agroalimentaria (Agroprospecta), 2009, 2010; Ireta *et al.*, 2015] takes into account groups of producers with similar technological level and growing area. The panel technique gathers a group of previously selected producers through a non-probabilistic and convenient sampling (Pimienta, 2000; Franco, 2018). The selection criteria were the willingness of producers with a similar technological level to participate in the survey.

Two panels were formed. Each panel was made up of ten pitahaya producers who received a direct invitation. Therefore, the survey was applied to 20 selected (expert selection) producers from a non-probabilistic sampling.

The panels were carried out from May to June, 2023.

Economic feasibility estimation

The indicators used to evaluate economic feasibility were: internal rate of return (IRR), net present value (NPV), and benefit-cost ratio (BCR). The results of these indicators were determined at the end of the cycle, once the initial investment and the total production (costs and income) were established (Mancilla *et al.*, 2020).

NPV was calculated with the following equation:

$$NPV = \sum_{t=1}^{T} \frac{B_t - C_t}{(1-i)^t} \quad (1)$$

The mathematical formal expression of IRR is an equation of the discount rate that equals NPV to 0 (Mancilla *et al.*, 2020).

$$IRR = \sum_{t=1}^{T} \frac{B_t - C_t}{(1-i)^t} = 0 \quad (2)$$

where: NPV = net present value ($); IRR = internal rate of return (%); B_t = annual benefit ($); C_t = annual costs ($); i = interest rate (%); T = number of analysis periods or lifespan of the project; t = each period of the project (year 1, 2... T); $(1+i)-1$ = discount factor.

Mancilla *et al.* (2009) established the following operation rule: if BCR is >1, the project is affordable; if BCR<1, the project is unaffordable; and if BCR $= 1$, there is an indecision. According to Mancilla *et al.* (2009) the BCR can be calculated with the following equation:

$$\frac{B}{C} = \left[\frac{\sum_{t-1}^{T} \frac{B_j}{(1+i)^n}}{\sum_{t-1}^{T} \frac{C_j}{(1+i)^j}} \right] \quad (3)$$

where: B_j = annual benefit ($); C_j = annual costs ($); i = interest rate (%); n = number of analysis periods or lifespan of the project; j = each period of the project (year 1, 2... T).

RESULTS AND DISCUSSION

Characteristics of the producers

The producers are divided into 75% men and 25% women. They are heads of family who are in average 48-years old and have an age range of 39 to 52 years. Unlike the results

recorded by Ayala *et al.* (2023), who mention that 78% of the members of the community of San Luis Atolotitlan, Caltepec, Puebla, are 50+ years old (which involves an ageing problem in the rural sector), 60% of the producers in Tepexi de Rodríguez are younger than 50 years. Additionally, they have a basic education level: 78% had concluded primary school and 22% had attended junior high school. They are interested in learning, innovating, and adopting new technologies. According to INEGI (2020), the average education level in the state of Puebla is 9.2 years among the 15+ year old population (*e.g.*, third year of junior high school). This figure is lower than the national average (9.7 school years among the 15+ year population). According to SAGARPA-FAO (2014), analyzing the education level of agricultural producers is particularly important, given its implication in their capacity to implement productive technologies and to manage production units.

Characteristics of production units

In average, production surfaces reach 1 ha. Producers mentioned that pitahaya is a commercial product and that their plantations are less than 6-years old. The local climate is ideal for pitahaya production, given that this xerophyte can adapt to dry and arid environments and diverse environmental conditions (Montesinos *et al.*, 2015). This versatility makes it an alternative in zones where other crops are restricted (Ricalde and Andrade, 2009).

The following activities are carried out during the first year of the crop: sowing, installation of the support system, installation of the irrigation system, application of organic fertilizer, and weeding. The plantation is established using plant cuttings with the help of support, mostly consisting of concrete structures or natural supports. In average, 3,300 plant cuttings and 1,550 supports are required per hectare. A concrete support costs approximately MXN$200, while a plant cutting costs MXN$35.00, resulting in an investment of MXN$521,843.10. The second-year maintenance tasks include the application of manure in May, as well as the application of varying quantities of fertilizers and pesticides in May, July, and August, depending on the conditions of the crop. The first harvest takes place during the second year. Although the production is rainfed, the initial plantation and production stages require additional water. Consequently, the May and June droughts have had a negative impact on production. The irregularity and lack of rain, as well as the high luminosity and temperatures damage and burn the plants during the winter-spring periods, reducing productivity and increasing production costs.

The fruit is harvested in three of fourth cuts, from June to October, recording an average production of 6 t/ha. This yield is possible as long as the plantation has been adequately cared for and has been irrigated at least twice.

Economic feasibility

The selling price is established according to quality. The base price per kg was MXN$45.00.

Prices vary according to offer and demand: the price is high at the start of the season and then it substantially decreases as the product offer increases or other fruits appear in the market (Flores, 2003). Annual income is projected with a useful life of 5 years

(Table 1). No profits are obtained during the first year, because the plants do not bear fruits and only sowing activities are carried out during that period (year zero). Plants bear fruits approximately one year after transplanting. Producers are not aware of any technology that can diminish the time before the harvest.

Table 2 shows the results of the analysis of costs and income, cash flow, and benefits and expenditures. The said results take into account investment, working capital, and surrender value.

Table 3 shows the up-to-date estimated costs and benefits, taking into consideration an updated 10% factor, investment in year zero, and income from the production of pitahaya from year 1.

Table 1. Total income (MXN $).

Concept	Year 1	Year 2	Year 3	Year 4	Year 5
Price	45,000.00	47,250.00	49,612.50	52,093.13	54,697.78
Tons	6.00	6.00	6.00	6.00	6.00
Total income	$270,000.00	$283,500.00	$297,675.00	$312,558.75	$328,186.69

Source: Table developed by the authors.

Table 2. Financial analysis, costs, benefits, and net flow.

Year of operation	Total Income	Project Investments				Valor de Rescate		Net Cash Flow
		Total Expenses	Fixed investment	Deferred investment	Working capital	Residual value	Recovery of working capital	
0		31,104	487,283.10		34,560.00			552,947.10
1	270,000.00	72,681.30						197,318.70
2	283,500.00	76,315.37						207,184.64
3	297,675.00	80,131.13						217,543.87
4	312,558.75	84,137.69						228,421.06
5	328,186.69	88,344.57				23,932.77	34,560	298,334.89

Source: Table developed by the authors.

Table 3. Up-to-date financial analysis, costs, benefits, and net flow.

Year of operation	Total costs ($)	Total benefits ($)	Discount factor 10.0%	Adjusted costs ($)	Adjusted benefits ($)	Discounted net cash flow ($)
0	552,947	0	1.000	552,947.10	0.00	−552,947.10
1	72,681	270,000	0.909	66,073.91	245,454.55	179,380.64
2	76,315	283,500	0.826	63,070.55	234,297.52	171,226.97
3	80,131	297,675	0.751	60,203.71	223,647.63	163,443.93
4	84,138	312,559	0.683	57,467.17	213,481.83	156,014.66
5	88,345	386,679	0.621	54,855.03	240,097.52	185,242.49
Total	954,557	1,550,413		854,617.47	1,156,979.05	302,361.58

Source: Table developed by the authors.

Updating cash flow is necessary to determine a net value, taking into account the long-term capital costs, therefore correctly determining financial indicators. Without updated incomes and expenditures, it would not be possibly to accurately determine the long-term capital cost (Mancilla *et al.*, 2009).

The NPV was higher than zero, while the IRR was higher than the discount rate. A 1.35 BCR indicates that a MXN$0.35 profit was obtained per each Mexican peso invested (Table 4).

Although pitahaya is a profitable crop (Table 4), commercialization has been problematic throughout the region, because producers must seek buyers or wait for their arrival.

According to Ayala *et al.* (2023), middlemen usually arrive at local pitahaya plantations; however, if the middleman does not visit the producer, the harvest will be lost, due to the lack of defined commercialization channels. Producers sell their pitahaya to middlemen, who determine the buying and selling price of the fruit; nevertheless, producers could obtain greater profits if they sold directly to the final consumers. According to Michel *et al.* (2022), the direct commercialization of pitahaya would be a feasible, effective, sustainable, and more profitable alternative for producers. Producers would then establish the selling prices throughout the fruit season. Likewise, adding value would be another alternative for pitahaya producers.

Pitahaya is not widely known in the domestic market; therefore, promoting non-traditional produces with development potential is a core task for the sustainable development of the agricultural sector. Additionally, fresh fruit does not have added value. However, given its nutritional value, pitahaya could have various market opportunities. Its properties help the successful treatment of several diseases (Lezama *et al.*, 2007). Appropriate market strategies could increase the demand for this fruit.

The prospects for domestic production lay mainly in the growth of internal consumption; therefore, advertising strategies are required to stress the exceptional characteristics of pitahaya, including its high nutritional content, health benefits, and versatile use in the kitchen. Such strategies could include using diverse communications channels (*e.g.*, social networks, TV, radio, and printed media) to reach the widest audience possible and organizing workshops, tastings, and cooking events to allow people to experience different ways in which they can consume pitahaya.

These activities could widen the consumer base, increase the commercial value of the fruit, and identify exportation opportunities to countries with high consumption of exotic fruits and gourmet products. Producers could also participate in international trade shows and establish alliances with distributing companies. According to Ayala *et al.* (2023), in

Table 4. Financial indicators.

Financial indicator	Value
Net Present Value (NPV)	$302,361.58
Internal Rate of Return (IRR)	28.29%
Benefit-Cost Ratio (B/C)	1.35

Source: Table developed by the authors.

order to position pitahaya in competitive markets and boost demand, a rural co-op system that allows producers to harvest and transform the fruit should be considered. Positioning pitahaya in the domestic market requires campaigns that make the population aware of its benefits and encourage its consumption. Pitahaya is a promising crop for small producers, as long as they establish appropriate agricultural management and demand grows.

CONCLUSIONS

Pitahaya thrives with minimum maintenance work and its production is profitable. Nevertheless, identifying commercialization channels for each harvest or a market niche specifically interested in pulp is essential. Meanwhile, the demand for this fruit should be increased beyond the local level. Its production on non-demanding zones is easy and feasible. It is not only a profitable fruit, but its consumption provides several benefits.

The profitability of pitahaya enables the improvement of its production, as well as the post-harvest management and development of its market positioning.

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