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Article

Pulque: an outlook from agribusiness

Yessica Viridiana Fernandez-Galicia[1]
Leticia Myriam Sagarnaga-Villegas[2,§]
José Maria Salas-González[3]
Marcos Portillo-Vázquez[4]

1 Doctorado en Ciencias en Economía Agrícola-División de Ciencias Económico Administrativas-Universidad Autónoma Chapingo. Carretera México-Texcoco km 38.5, Chapingo, Texcoco, México. CP. 56230. Tel. 595 9571094. (yfernandez@ciestaam.edu.mx).

2 División de Ciencias Económico-Administrativas-Universidad Autónoma Chapingo. Tel. 55 69604830.

3 División de Ciencias Económico-Administrativas-Universidad Autónoma Chapingo. (jsalasg@chapingo.mx).

4 División de Ciencias Económico-Administrativas-Universidad Autónoma Chapingo. Tel. 595 1067647. (mportillo49@yahoo.com.mx).

Autor de correspondencia: lsagarnagav@chapingo.mx

Abstract

Pulque is a fermented alcoholic beverage originating in Mexico, made from the fermentation of aguamiel extracted from *Agave salmiana* and other species, and its exploitation is concentrated in the central region of Mexico. In recent years, its consumption has increased due to a greater appreciation of national identity and its natural nature free of conservatives. The increase in consumption has encouraged farmers to invest in planting this variety of agave. Nevertheless, there is scarce scientific literature on the profitability of this productive activity. This research contributes to identifying the profitability of the crop by estimating production costs and revenues of a representative production unit located in Coatepec, Ixtapaluca, Mexico. The information was collected through producer panels in 2021, the data were processed according to the methodology of the association of agricultural economists of the United States, adapted for Mexico. The production of pulque in the conditions and region described is a profitable agribusiness, mainly due to the level of integration of the production chain, low transaction costs, and sales in short marketing channels; it is recommended to expand economic studies in other pulque-producing areas and evaluate competitiveness.

Keywords:

Agave salmiana, aguamiel, economic feasibility, production costs.

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Introduction

In Mexico, magueys or agaves are plants of great cultural, ecological, and economic importance; fragments of history are interwoven around them, so they are considered part of the national identity. The maguey is endemic to America; taxonomically, it is located in the Agavaceae family (Granados-Sánchez, 1993); as proposed by García-Mendoza (2011), there are 340 species, of which 261 are found in Mexico.

Two types of beverages are obtained from agave, undistilled and distilled (Arrizón *et al*., 2007). Among the undistilled beverages, pulque is considered the most emblematic and iconic pre-Hispanic drink in Mexico (Gonçalves de Lima, 1990). According to various authors, pulque is obtained mainly from the agaves *A. atrovirens*, *A. mapisaga*, and *A. salmiana* (Escalante *et al*., 2013); however, there are other species from which aguamiel is also obtained for the production of pulque, such as *A. hookeri*, *A. americana*, *A. teometl* Zucc, *A. weberi* Cels., *A. altisima* Jacobi., *A. compliala* Trel., *A. gracillispina* Englem., *A. malliflua* Trel.; among the most used to produce pulque is *Agave salmiana* because better yields are obtained from this species; therefore, it was selected as the object of study in this research.

Pulque is the product of the fermentation of the sap or aguamiel of agave pulquero; aguamiel is a translucent liquid with a sweet and fresh flavor, obtained from scraping the maguey pulquero stem, which, when fermented, produces a thick, white, viscous, slightly acidic alcoholic beverage, with an alcohol content ranging from 4 to 7% (Escalante *et al*., 2016).

Pulque is an important source of prebiotics and probiotics that have various biological activities to promote health. Gutiérrez-Uribe *et al*. (2017) point out that the complex microbiota of pulque is affected by the production process, climatic, edaphic and aguamiel collection conditions, so the quality and nutritional contribution is different for each production area.

According to SIAP (2021), in 1994, the area planted with maguey reached an all-time high of 16 912 ha. Since then, the planted area has undergone fluctuations with a tendency to stabilize. In contrast, the price shows a significant increase, taking the price of aguamiel for 2000 as a reference, the average rural price per liter was $1.67 pesos (SIAP, 2021) and for the year 2021, it was marketed at $4.05 pesos.

This process of revaluation has provided the conditions for the crop to be attractive in economic terms for farmers who had stopped planting maguey pulquero. The increase in the value of production is an indicator that pulque continues to be a popular drink; currently, its consumption has expanded not only to pulquerías, but it is also marketed in restaurants, neopulquerías, tianguis, and street points of sale (Blas-Yañez *et al*., 2018) and due to the Covid 2019 pandemic, sales have diversified through distribution on websites.

In order of importance, the production of maguey pulquero is concentrated in the states of Hidalgo, Tlaxcala, Puebla, and in fourth place is the State of Mexico. The research was carried out in the latter state in the community of Coatepec, municipality of Ixtapaluca, which is located in the east of the Valley of Mexico. The consumption of pulque has become widespread not only in the center of the country; it has expanded to states such as Chihuahua, Sonora, Sinaloa, Baja California and even to the United States of America; the promotional activities carried out by groups allow attracting young consumers (Lappe-Oliveras *et al*., 2008).

Pulque has been studied from different points of view (Gonçalves de Lima, 1990); nevertheless, there is little or no information that allows us to know the revenues, costs, and profits of this activity and its derivatives. Profit is understood as the difference between the value of the final products and the value of the factors of production used (Rasmussen, 2011).

The objective of this study was to provide economic information that can guide decision-making. To achieve this, the revenues and production costs of maguey pulquero in Coatepec, Ixtapaluca, State of Mexico are analyzed and the factors that influence them are identified. This is done by considering three different processing and marketing scenarios in order to propose strategies to improve its viability.

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Materials and methods

The research makes a quantitative descriptive analysis that allows outlining the general conditions of the production of maguey pulquero in the area under study. The technical and economic information that supports the research was collected through the technique of producer panels, with which a process of analysis, discussion, and consensus of expert producers was carried out, and a representative production unit (RPU) was modeled.

Marshall (1980) introduced the concept of representative production units to describe a company whose performance is representative of a specific sector. The panel technique is an adaptation of the Delphi technique (Torrado-Fonseca, 2016) through which information is collected from a panel of expert producers, whose task is to build a model RPU and approve its ability to reasonably reflect the economic activity of the production units they represent (AFPC, 2021); therefore, a panel made up of producers with technical characteristics of size and level of assets that are representative of the region of study is required.

To build the RPU, two panels were held in 2021, one for data collection and the other for the validation of the findings. The main sources of information were five maguey pulquero producers, selected through non-probabilistic sampling of expert selection (Pimienta, 2000); the selection criteria of the participants were homogeneity in production scale, technological level, as well as similar management and marketing capacities; in addition, it was contemplated that the panelists were considered opinion leaders producers in the analyzed community, characteristics difficult to achieve through probability sampling.

During the panel, the panelists were asked to describe the agronomic work to obtain aguamiel and pulque, as well as detail information on inputs, infrastructure, machinery, equipment, payment of salaries, destination of production, type of labor, prices, and revenue. The information collected was used to model the RPU called COMGY01. The acronym refers to the location (CO: Coatepec, State of Mexico), product analyzed (MGY: Maguey), and scale of production (01: 1 hectare); its economic and financial viability is analyzed in this work.

To estimate the costs in this research, the methodology developed by the committee of information resources and economic statistics of the American association of agricultural economics (AAEA, 2000) was used, which provides a theoretical and methodological basis for the estimation of costs of agricultural products.

The established criteria are currently used by the Economic Research Service (ERS) of the Department of Agriculture of the United States of America for the estimation of costs of agricultural products and has also served as a reference for the design of a methodology applied to the Mexican agricultural sector (Sagarnaga *et al*., 2018). Once annual costs and revenues were estimated, net cash flow, financial viability, and economic viability were calculated.

Cash flow indicates the balance resulting from revenues minus disbursed costs (Kousenidis, 2006) and indicates the company's ability to meet its short-term obligations. It is also used for the calculation of the internal rate of return or investment (IRR), defined as the profitability of the company or an investment project, mathematically expressed as the discount rate that, when applied, equals the net present value to zero (Ramírez, 2019); that is, it is the maximum interest rate at which the project or company evaluated can borrow or it is the interest rate provided by the project.

Financial viability includes the depreciation of the means of production and is used to measure the company's ability to meet its medium- and long-term obligations. If the result of this analysis is negative, the company may not remain in business. Economic viability includes the opportunity cost of the factors of production (land, labor, and capital). If the result is negative, the company is unable to cover the opportunity cost of the factors of production, so the resources could be transferred to a more profitable alternative activity.

The baseline corresponds to COMGY01 as modeled by the producers, with the sale of aguamiel (15%), pulque production (80%), and self-consumption of aguamiel (5%). From this, two production

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and marketing scenarios were projected; a first scenario considers the alternative of allocating 100% of aguamiel to the production of pulque (COPU01) and the second considers that all the aguamiel is marketed fresh (COAGM01).

For the analysis of these scenarios, the cost of production of pulque was disaggregated from the total costs reported for COAGM01. In the COPU01 model, the cost per liter of pulque includes the cost of producing aguamiel plus the costs of the tinacal (place where the fermentation container are stored), as well as distribution and marketing costs. For the COAGM01 scenario, only the costs of production of aguamiel are included.

Results and discussion

According to the panelists, the modeled RPU, COMGY01, is representative of the large-scale production units in the analyzed community, which have the following characteristics: the area is 1 ha in rainfed land, the type of property is for common use, they have their own nursery where future plants are propagated, they fertilize with organic cattle manure, the crop density is 1 500 plants ha^{-1}.

A 10% loss was estimated, mainly due to pests, diseases, and the illegal extraction of the leaves for mixiote (a Mexican dish), which affects the growth of the plant. *Agave salmiana* variety 'Ayoteco' is used; the duration of the plantation is 14 years, of which three are in the nursery and 11 for its development in the final plantation. There are three methods of propagation of the maguey: by suckers, seed, and *in vitro*; however, the method most used by farmers is by suckers, which are shoots that sprout from the rhizome of the maguey and constitute new plants (Enciso, 1950).

This method is the most used in the region of analysis; for this method, it is necessary to establish a nursery for the adequate growth of the suckers and when they reach the required size they are transplanted to the final plantation. For the establishment of the nursery, required for one hectare of maguey, an area of 1 500 m^2 (1 500 plants, one meter per plant) is needed.

The first activity to be carried out is mechanical fallowing, then furrowing and clearing of the land. With the ground ready, the 17 cm suckers are plucked from the mother plant. They are then planted and fertilized with cattle manure at the rate of one wheelbarrow per plant. The stay in the nursery is three years, the cultural work carried out is fumigation once a year, weeding three times a year, and pruning twice a year from the second year onwards.

In the region, it is common to plant with the ximini, manso and carricillo varieties; nonetheless, the Ayoteco variety is preferred by farmers in the region because it generated higher yields and was the variety used for this modeling. Each plant generates three vigorous marketable suckers on average. In the third year and with a height of 80 cm, the plant is uprooted and put in the sun (airing) for a period of two to three months before being transplanted, the labor used for the uprooting must be specialized to avoid excessive mistreatment, then the plant is transferred to the place of the final plantation with trailers.

The establishment of the final plant begins with the preparation of the land; it is mechanically fallowed and then harrowed to eliminate the clods, holes measuring 1 m^2 by 50 cm deep are made with machinery. The planting is done by hand, taking care not to leave the plant completely buried and three wheelbarrows of bovine manure are applied per plant. The best date to plant is just before the rainy season.

The cultural and maintenance activities carried out in the plantation are weeding (two each year, from the first to the fifth year of planting), pruning (two each year, from the second to the sixth year), loosening (one a year in the second and third years) and chopping (two each year, from the sixth to the eleventh year). All made manually with hired labor.

The castrating (removing of the scape) of the maguey marks the beginning of the exploitation, which is carried out from the tenth to the eleventh year of the establishment of the plant. The tlachiquero (person that scrapes the maguey) determines the moment when each maguey should be castrated, before the flowering of the scape; thus, a cavity that stores the aguamiel is formed, a bad procedure in the castrating will imply lower yields of aguamiel.

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After castrated, it is left to age for five to seven months. To determine the castrating of the maguey, prior and in-depth knowledge is required, which is consistent with what other researchers have found (Parsons and Parsons, 1990); therefore, the labor employed in this activity is considered specialized. At the end of the maguey aging time, the scraping to obtain the aguamiel begins, this stage lasts an average of four months.

The way to organize the exploitation of the maguey is in batches of 25 magueys; therefore, an average of eight tlachiqueros are required per year with a payment of $705.00 pesos per plant exploited. The panelists said that, on average, 575 plants are exploited per year. The activities carried out by the tlachiquero are monitoring of the maguey, castrating, scraping, extraction of aguamiel and transfer of the aguamiel to the tinacal. The scraping is done daily in the morning and in the afternoon, obtaining an average of 10 L of aguamiel per day per plant.

In this stage of exploitation, approximately 200 live magueys (castrated plants) are sold due to the inability of the COMGY01 to exploit them for the production of pulque. In this way, excessive ripening is avoided, the plants are sold only to other farmers, tlachiqueros or pulqueros in the community. Therefore, of the 1 500 plants, 1 150 plants ha^{-1} are used. This is because 200 are destined for sale to other farmers and 150 are lost due to shrinkage.

Other studies suggest densities ranging from 1 000 to 2 000 plants ha^{-1} in Zacatlán, Puebla and 1 750 plants in Calpulalpan, Tlaxcala (Álvarez Duarte *et al*., 2018). An average of 1 200 L of aguamiel is extracted from each plant (5.5 L in the morning and 4.5 in the afternoon), a figure that coincides with what was found by Guerrero and Castro (2013). Consequently, each hectare in the analysis region has an average yield of 1 380 000 L of aguamiel from the 1 150 plants.

The use of aguamiel in the COMGY01 RPU is distributed as follows: 80% (1 104 000 L) for the production of pulque, 15% (207 000 L) is sold as aguamiel and 5% (69 000 L) is destined for self-consumption. The quality and quantity of aguamiel will depend on the soil conditions, the variety of agave, the conditions of the crop, the relative humidity, as well as the season of the year (Sánchez, 1970).

In the rainy season, aguamiel production decreases. The pulque production process is artisanal and backyard, the way of producing has not changed since pre-Hispanic times, it was carried out in rustic facilities in a roofed space and with walls, in an approximate area of 100 m^2. The space must have adequate ventilation, a cement floor and basic services such as electricity, drainage, and drinking water.

Three fiberglass vats, water jars, buckets, strainers, and cleaning equipment in general are required. As for personnel, a butler and an assistant are required, who are hired all year round from the beginning of the exploitation and are in charge of receiving the aguamiel, cleaning and growing the pulque (which means taking care of the proliferation of pulque), serving customers and sending orders, all under the supervision of the owner of the RPU.

Fermentation takes place in fiberglass vats; the aguamiel is filtered and poured into the vats along with the previously added seed, the seed is the previous mixture that gives the special touch to pulque (Montes, 2014), it is the inoculum that begins the fermentation process. Once in the vats, the fermentation process lasts between four and five hours (Escalante *et al*., 2016).

The result obtained, in terms of flavor and consistency, depends a lot on the quality of the aguamiel. According to the data obtained through the panel, the yields are: 1 L of aguamiel to obtain 700 ml of pulque; therefore, from 1 104 000 L of aguamiel, 708 400 L of pulque is obtained, also discounting 8% of the loss caused by the rains, according to the panelists.

The density of the crop and the time required of COMGY01 coincide with the description made by Ramírez *et al*. (2020) of a plantation located in Nanacamilpa, Tlaxcala, which is considered an intensive production system and one of the most important pulque-producing farms in the country with the best productive indicators. For this reason, and with the data obtained for COMGY01, it is considered a high-density unit in the national standards of aguamiel and pulque production.

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In the production of maguey pulquero, the main operating cost is the hired labor (Table 1), most of the activities within the plantation are carried out manually. Specialized labor is paid at $300.00 pesos day^{-1}, plus food and pulque, traditionally provided by the farmer. In total, one hectare needs 209 labor days of field workers plus specialized plant workers such as the tlachiquero, the butler and the butler's assistant.

Table 1. General costs in pesos for COMGY01.

Costs	Establishment nursery	Maintenance nursery	Establishment plantation	Maintenance established plantation	Production of pulque	Total
Hired labor	2 700	35 700	17 700	927 600	374 400	1 358 100
Energy	300	300	300	9 730		10 630
Miscellaneous	400	800	500	16 200		17 900
Business management	6 000	6 000	6 000	702 000	156 000	876 000
Marketing expenses				1 680	196 000	197 680
Maintenance and repairs				51 590		51 590
Organic fertilizer	12 800		25 600			38 400
Maquila	4 800		25 100			29 900
Agrochemicals		2 250				2 250
Water		300				300
Tools and materials	6 000			24 000	44 000	74 000
Inputs					21 000	21 000
Total	33 000	45 350	75 200	1 732 800	791 400	2 677 750

Elaboration from field information.

The item of labor represents 51% of total operating costs. Producers report that it is difficult to find the labor required for the activity, so they must offer competitive salaries and maintain additional benefits that allow them to maintain specialized labor. The item of business management, an activity carried out by the producers themselves, is paid with a salary of $6 000.00 pesos per month, throughout the year, which represents 33% of the operating costs. Together, contracted labor and business management represent 84% of the total amount of operating costs.

The general costs incurred in the plantation amount to a total of $174 727.00 pesos (Table 2), 54% correspond to the item of depreciation of assets, which turned out to be low compared to other activities related to the sector. Farmers do not use any type of loan, investment is leveraged with their own resources, and there is little investment in infrastructure.

Table 2. Operational, general, and opportunity costs ($ ha^{-1} in 2021).

Item-type of cost	Economic	Financial	Cash flow
Operational	2 677 750	2 677 750	2 677 750
General	174 727	174 727	
Opportunity	576 135		
Total	3 428 612	2 852 476	2 677 750

Elaboration from field information.

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By including the opportunity cost of the factors of production: land, labor and capital, the costs increase by 20% compared to the financial costs. This coincides with the results of previous studies that indicate that the value of land increases costs and changes percentage structures (Ramírez *et al*., 2015), confirmed by Domínguez *et al*. (2017), who found that opportunity costs on factors of production increase production costs.

The data collected were used to estimate the unit production costs (Table 3) for the liter of aguamiel ($2.48 pesos); it was $1.40 pesos lower than the average rural price reported by SIAP (2021) for the State of Mexico. In the case of pulque, the production cost ($4.83 pesos) was lower than the sale price ($8.00 pesos), generating a profit of $3.17 pesos, but it was not the case in plants, where the production cost ($2 539.00 pesos) is higher than the sale price ($1 500.00 pesos).

Table 3. Production costs. COMGY01 2020 (unit pesos).

Item	EC	FC	IC	Sale price	Profit (%)
Hectare	3 428 612	2 852 476	2 677 750		
Liter of aguamiel	2.48	2.06	1.94	6.00	142
Plant	2 539	2 112	1 983	1 500	-40
Liter of pulque	4.83	4.02	3.78	8.00	45

Elaboration from field information.

The RPU has integrated all the links in the production chain, which coincides with Álvarez *et al*. (2018) as part of the typologies of producers, which represented an advantage in relation to other producers. This advantage is enhanced thanks to the proximity of the COMGY01 to the City of Mexico and its metropolitan area, which represents the largest market for pulque consumption. Natural pulque is marketed to retailers in the Valley of Mexico, Mexico City, and the Izta-Popo area.

According to the panelists, in the study area, it is common for farmers to sell pulque in their homes, a situation that has led to the opening of restaurants, and other business models that are not addressed in this research, but that have been identified as short marketing circuits.

Short marketing circuits are those channels where the number of intermediaries between the farmer and the consumer is minimal or ideally zero (Kneafsey *et al*., 2013), which guarantees added value for farmers and allows consumers to support the local economy by sustaining small farms (Dragicevic, 2021).

This strengthens the argument found by Fierros and Ávila (2017), who argue that profitable family business owners are the closest to cities, which facilitates access to markets and reduces transaction costs. The revenue of COMGY01 not only depends on the sale of pulque; in the revenue analysis, it was found that maguey begins to generate products from the nursery stage through the sale of suckers obtained from the second year and are the main income in the nursery stage, together with the sale of chinicuil (larvae of a moth that live in maguey leaves).

In the established plantation stage, revenue is obtained from the sale of leaves, which are sold to barbacoa makers in the region or sold to intermediaries who sell it in the supply center of Mexico City. The leaves are obtained from the third to the sixth year; an average of eight leaves are cut per plant, which gives a total of 10 800 leaves ha^{-1}, which are sold at a price of $4.00 pesos each.

In the fifth year, 250 ml of chinicuil is extracted; this product has little impact on revenue since it is a pest that producers prefer to eliminate and replace the plants that have it. For the castrated plant sold, revenues of $300 000.00 pesos are recorded. An estimated 1 380 000 L of aguamiel is obtained from one hectare; of which 80% (1 104 000 L) is destined for the production of pulque, 15% (207 000 L) is marketed as fresh aguamiel without any type of processing, and 5% (69 000 L) is destined for self-consumption and is used in the production of atoles, honeys, remedies and as gifts for family, friends and customers (Table 4).

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Table 4. Unit and total revenue of COMGY01 2021 ($).

Item	Unit sale price	Units	Total
Plants (pieces)	15	4 050	60 750
Chinicuil (L)	3 000	2.25	6 750
Leaves (pieces)	4	43 200	172 800
Aguamiel (L)	6	207 000	1 242 000
Castrated plant (pieces)	1 500	200	300 000
Aguamiel self-consumption (L)	6	69 000	414 000
Pulque (L)	8	708 400	5 667 200
Total revenue			7 863 500

Elaboration from field information.

According to the methodology, self-consumption was considered only in economic income because it does not generate monetary income, but it does bring a benefit to the RPU. This is the main difference in economic and financial income. In total, in an area of one hectare, this crop generated a cash flow of around 7.5 million pesos and total revenues close to almost 8 million pesos; however, the cash flow is negative until the twelfth year of the crop, 43% of total expenditures must be invested in these years; in contrast, only 3% of the revenue is received in that same period.

This forces producers to invest resources from other sources to finance the activity during this time, which are recovered in the last two years of the crop's life. Considering the 14-year life of the crop, the positive ending cash balance indicates that the RPU is capable of meeting all its medium- and long-term obligations (Table 5).

Table 5. Revenue, costs and balance of COMGY01, 2021 ($ ha^{-1}).

Item	Economic	Financial	Cash flow
Revenues	7 863 500	7 449 500	7 449 500
Total costs	3 428 612	2 852 476	2 677 750
Balance	4 434 887	4 597 023	4 771 750

Elaboration from field information.

The estimated IRR for COMGY01 was 23%, which is higher than the interest rate paid by banks (5.6%); therefore, investing in maguey pulquero plantation is profitable under the production conditions described. From the financial point of view, it was found that the most profitable productive alternative is to sell the total of unprocessed aguamiel; nevertheless, from a commercial point of view, this scenario is not very viable since there is currently no buyer with the capacity to absorb the volume of aguamiel generated in the region (Table 6).

Table 6. Marketing alternatives COMGY01, COPU01 and COAGM01 in 2021 ($).

Item	COMGY01	COPU01	COAGM01
Cost ($ ha^{-1})	3 428 612	5 467 230	2 860 527
Cost ($ plant^{-1})	2 539	4 049	2 118
Cost of aguamiel ($ L^{-1})	2.48	3.37	2.07
Cost of pulque ($ L^{-1})	4.83	5.25	
Revenue	7 863 500	8 556 300	8 820 300
Total costs	3 428 612	5 467 230	2 860 527
Profit	4 434 887	3 089 069	5 959 772
IRR	23%	16%	26%

Elaboration from field information.

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The alternative of converting the total of aguamiel into pulque was less profitable; therefore, the alternative currently followed by producers of selling part of the production of fresh aguamiel and part transformed into pulque is the most appropriate.

Conclusions

With the analysis carried out, it is verified that the production of maguey pulquero turned out to be a profitable agribusiness alternative under intensive production conditions. Despite the barrier to entry that means the time required for the exploitation of a maguey pulquero. A result to highlight is the strong impact that labor has on the cost structure of the plantation since it reaches 80% of the total costs because it is a manual and highly specialized activity; therefore, it is important to preserve and transmit ancestral knowledge about crop management and mainly the activities carried out by the tlachiquero.

The most important factor that has allowed this value network to be profitable is its ability to be integrated throughout the production chain, from production to marketing, which reduces transaction costs and guarantees a quality and continuous supply in the chain. In other regions, the supply in quantity and quality, or the intervention of a collector, represents a high cost that reduces the profit margin for farmers.

Therefore, the strategic territorial position in the community allows farmers to market through short marketing circuits and capture a greater share of value for their product. The data obtained shows that there is a positive economic outlook for the national pulque economy in the coming years, but it is necessary to delve into economic issues related to the maguey pulquero value chain. The limitation of the study lies in the fact that the data describes the characteristics of a particular region in Mexico, but it is the watershed to know basic economic indicators of the maguey pulquero production chain.

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