Collection and silage of agave leaves in two communities of Guanajuato, México, as a business alternative

Colecta y ensilaje de hojas de agave en dos comunidades de Guanajuato, México, como una alternativa de negocio

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Abstract

Some Mexican spirits are made with agave cores; however, the leaves are rarely used and transformed into something useful. In this work, we aim to determine if ensiling agave leaves can generate an economic income in two agave-producing communities in Guanajuato. The leaves were collected, transported, and ensiled to achieve it, and the benefit-cost ratio was determined. Also, the production of agave leaves in Guanajuato was estimated during 2017-2021. The benefit-cost ratio for La Grulla and San Vicente was 1.18 and 3.02, respectively. These data suggest that in addition to the sale of the agave cores, collecting agave leaves and their silage could generate extra income.

Keywords: agave leaves, silage, benefit-cost ratio.

Resumen

Algunas bebidas alcohólicas mexicanas son elaboradas con la piña de agave; sin embargo, las hojas, raramente son usadas y transformadas en algo útil. Se pretende identificar si al ensilar las hojas de agave se puede generar un ingreso económico en dos comunidades productoras de agave en Guanajuato. Las hojas se colectaron, transportaron, ensilaron y se determinó la relación costo-beneficio. Además, se estimó la producción de las hojas de agave en Guanajuato durante el 2017-2021. La relación costo-beneficio para La Grulla y San Vicente fue de 1.18 y 3.02, respectivamente. Estos datos sugieren que adicional a la venta de la piña, colectar y ensilar las hojas de agave puede generar un ingreso extra.

Palabras clave: hojas de agave, ensilado, relación costo-beneficio.

Introduction

Agaves or magueys (*Agave* spp.) are plants strongly linked to the history and culture of Mexico and are mainly used to make spirits, where tequila is the most widely produced and, by far, the most popular

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(Gutiérrez-Coronado *et al*., 2007; Davis *et al*., 2015; Reta Sánchez *et al*., 2015; López Feldman & Hernández Cortés, 2016; Pérez-Zavala *et al*., 2020). This popularity has increased tequila production yearly; for example, 651.4 million liters were produced in 2022, a 24% increase over 2021 (CRT, 2023). Because spirits like tequila have a denomination of origin, production is limited to specific regions of Mexico. The state of Jalisco, for example, is well-known for its agave and tequila production with Protected Designation of Origin (PDO) in different municipalities. In addition, Guanajuato also has the PDO for tequila and mezcal in some of their municipalities (CRT, 2023; COMERCAM, 2022; SIAP, 2023), which has favored the increase in the agave crops (e.g., *A. tequilana* Wever var. azul and *A. angustifolia*). Undoubtedly, spirit production has benefited the local economies but also favored an increment in the agave by-products (i.e., agave leaves) that are rarely used or adequately discarded, even though they possess nutraceutical properties (Huezcas-Garrido *et al*., 2022; Álvarez-Chávez *et al*., 2021) or can be used, among other things, to produce food (e.g., mushroom) or silage (Cruz-Moreno *et al*., 2023; Pinos-Rodríguez *et al*., 2009).

To produce spirits, agave plant cores are harvested from mature agave plants using a traditional process called *jima*. During the *jima*, the entire agave plant is not sold, and the remaining agave leaves are usually left to rot or burned. In this sense, we have yet to find in the literature a scientific work related to incorporating agave leaves into the soil for *in situ* composting. Leaves are frequently burned on-site, resulting in a negative impact on the environment, human health, and the composition of the soil microbiota-which is critical for soil health and crop performance. Reducing greenhouse gas emissions is an important key climate strategy (Pérez-Zavala *et al*., 2020.). People usually do not use agave leaves for other purposes partly because they consider that the cost of collecting, transporting, and processing the crop by-products is high and not profitable (Das *et al*., 2020; Lin & Begho, 2022). Nonetheless, while many farmers consider agave leaves as waste, it has been demonstrated that they are by-products that can be subject to anaerobic fermentation to ensile them or extract bioactive compounds (Bermúdez-Bazán *et al*., 2021).

Based on the above, the agave leaf silage can be an excellent option for cattle food, mainly when there is a shortage of fodder due to a lack of rain (arid or semiarid areas) (Garcés Molina *et al*., 2004; Pinos-Rodríguez *et al*., 2006). Besides, there are other advantages of feeding cattle with agave leaf silage, for example, it has been observed an increment in the ruminal fermentation and nitrogen balance (Pinos-Rodríguez *et al*., 2006, 2009; Álvarez-Fuentes *et al*., 2015; Parra Negrete y Tortolero Cervantes, 2016; Cummins, 2020), reduction of saponins (Castro Rivera *et al*., 2016), and a gain of weight when it is added to commercial food (Reyes-Castro *et al*., 2022). Because agave leaf silage is water-free, it can be preserved for months and used for self-consumption to feed the cattle when the *agaveros* have farm animals, reducing the forage purchase and cattle feed costs (Pinos-Rodríguez *et al*., 2006, 2009; Álvarez-Fuentes *et al*., 2015; Cummins, 2020). If the agave leaf silage is not used for self-consumption, it can be commercialized, generating extra economic income.

To date, it has been published different procedures to obtain agave leaf silage of different species of agave and demonstrated that they could be an option to be used in cattle feed (Pinos-Rodríguez *et al*., 2009; Reta Sánchez *et al*., 2015; Reyes-Castro *et al*., 2022); however, there is little data about what the cost is to produce them starting from the collection of agave leaves (Morales González *et al*., 2009; Villalobos Villalobos *et al*., 2015). The lack of information motivates us because agave leaves are a bioproduct that can be sustainably transformed into something useful and generate extra income, i.e., Bioeconomy. Here, our objective is not to enter in detail into the silage process but to determine the costs of the collection, transport, and ensilage of agave leaves (CTEAL) in two communities of Guanajuato and the cost-benefit ratio to generate information that can help decide whether it is worth collecting and producing agave leaf silage. Besides, we estimated the tons of agave leaves produced in Guanajuato during 2017 and 2021 to show the amount of the agave by-product that can be used to create an income source.

1. Material and methods

1. 1. Collection and transportation of agave leaves

We consulted several agave crop owners from different municipalities of Guanajuato. In most cases, they were unavailable to participate in the work for various reasons, for example, that the agave was not ready for the *jima*. Finally, owners from the Grulla and San Vicente located at San Francisco del Rincón and Irapuato Guanajuato, Mexico, respectively, showed us the desire to provide agave leaves for the study. Agave leaves from *Agave* spp. were collected manually in La Grulla and mechanically in San Vicente communities during the *jima* process (figure 1). In La Grulla, the leaves were manually loaded into a trailer and then transferred to a warehouse within the same property where they were later ensiled. On the other hand, in San Vicente, the leaves were stacked with a rake pulled by a tractor to carry out the automated collection. The leaves were then loaded into a cargo truck with a backhoe and transported to a warehouse in Salamanca, Guanajuato (about ~40 km away), where they were ensiled. The costs generated in each step during collecting and transporting the agave leaves in La Grulla and San Vicente were recorded, including the crushing machine price, silage bags, urea, and labor (table 1, table 2).

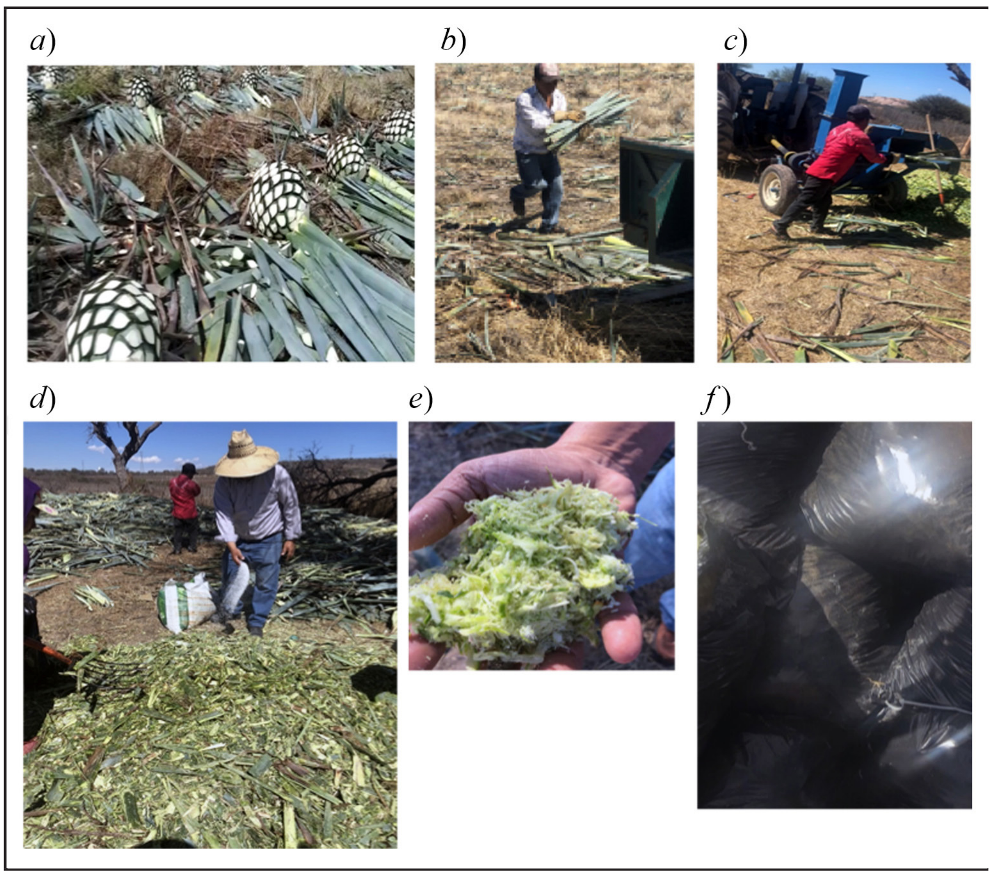

FIGURE 1
Collection and silage of agave leaves collected in La Grulla, municipality of San Francisco del Rincón

Note: *a*) = During the *jima*, the leaves were separated from the core (material used to prepare distilled alcoholic beverages). *b*), *c*) = The agave leaves were collected manually and passed to a shredder within the same farm. *d*), *e*), *f*) = The crushed leaves were supplemented with urea and placed in bags; then, the air was removed and stored at room temperature to make the fermentation process and produce silage.

1. 2. Silage

Agave leaves were crushed, mixed with urea (10 kg urea/t), and placed in black plastic bags to make the silage. The air from the bags was removed to create anaerobic conditions and then sealed to facilitate fermentation for 30 days at room temperature (figure 1). To determine the cost of the inputs for making the silage, we consulted prices on the websites of stores specializing in making silage and the prices from local stores. Additionally, the costs of the most common commercial forages were recorded, and a tentative cost of the agave leaf silage was estimated. We considered that one kilogram of agave leaves yields approximately one kilogram of silage. The benefit-cost ratio in each community was calculated by dividing the total cost of the CTEAL process by the total income. This ratio was used to determine if agave silage production is profitable as a business alternative.

1. 3. Data collection

The production of tons of agave leaves and silage was estimated using data collected from the Servicio de Información Agroalimentaria y Pesquera (Agrifood and Fisheries Information Service) (SIAP, 2023). Besides, we determined the potential income generated by ensiling and marketing them. The agave leaves production per hectare can vary depending on several factors, for example, the species of agave, the variety, and the type of irrigation. Here, to determine the benefit-cost ratio, it was estimated that a harvested hectare of agave produces 60 to 100 tons of leaves (INIFAP, 2019; Panorama Agrario, 2016). Finally, agave production was investigated in Guanajuato for a period of five years (2017 to 2021) to estimate the amount of agave leaves produced in the state (SIAP, 2023).

2. Results

2. 1. Collection and transport of agave leaves from La Grulla

During the *jima* process, the leaves were separated from the core. Three workers were hired to manually collect and separate the green leaves from the dry ones. Approximately five tons of green agave leaves were collected, transported by trailer, and stored in a warehouse on the same property. A total of 1 890 Mexican pesos (hereafter "MXN") was paid to collect the five tons of agave leaves, resulting in a cost of 378 MXN/t and 0.378 MXN/kg of agave leaves collected (1 890 MXN/5 000 kg agave leaves) (table 1).

2. 2. Silage of agave leaves from La Grulla

The leaves stored within a warehouse were crushed and ensiled in the same place. With a rented machine, the leaves were crushed, generating particles of approximately 5 cm. The crushing machinery was rented for 3 000 MXN per week, allowing a three-person labor force to crush and silage five tons of leaves in three days. The three workers were paid 620 MXN per day for their labor. The five tons of shredded leaves were put into 25 kg bags. 50 kg of urea were mixed with five tons of crushed leaf (10 kg urea/t) (table 1).

Several forage stores were consulted to estimate the potential income that could be made from ensiling and marketing them. It was observed that most commercially available fodders are made from corn, sorghum, ground alfalfa, cane weeds, oil pastes, and citrus pulp, but not from agave leaves. The fodders are sold at prices ranging from 3 to 5 MXN/kg and are meant to feed cattle, goats, and sheep. If the agave silage described in this work was sold for 2 MXN/kg, an income of ~10 000 MXN (5 000 kg x 2 MXN) would be obtained. Given that the cost of processing 5 000 kg of agave leaves into silage is 8 450 MXN, the price per kilogram of fodder is approximately 1.69 MXN (table 1), implying a net profit of 2 MXN/kg. It indicates that an agave plantation owner can earn about 1 550 MXN (10 000-8 450 MXN) per 5 t of processed leaves.

TABLE 1

Costs generated during the collection and transformation of 5 t of agave leaves collected manually in the La Grulla and transformed into silage*

Description	Unit Price (MXN)**	Total price (MXN)
Crusher machine rental	-	3 000
Tractor rental	-	750
Cost of silage bags	1.50	300
Gasoline, electric light	-	300
Urea (50 kg)	350	350
Labor for collecting leaves	-	1 890
Labor for the silage	-	1 860
Total cost of 5 000 kg of silage	-	8 450
Cost of kilogram of silage	-	1.69

Note: *1 kg of blue agave leaves produces approximately 1 kg of silage. Agave leaves were collected by hand.

2. 3. Collection and transport of agave leaves from San Vicente

The agave leaves from San Vicente were collected mechanically. A raking machine was rented for 500 MXN/h, using four hours to collect all the leaves (i.e., 2 000 MXN). Subsequently, a backhoe was used to lift and deposit the leaves in a cargo truck to be transported to Salamanca Guanajuato, Mexico, where they were ensiled. The backhoe was rented for eight hours at a rate of 550 per hour (4 400 MXN). The cost of transportation to Salamanca was 2 500 MXN per freight (total of 6 freights, 15 000 MXN). The price for collecting and transporting 67.2 t of agave leaves was 21 400 MXN, representing a cost of 318.4 MXN/t (i.e., 0.318 MXN per kilogram of agave collected) (table 2).

TABLE 2

Costs generated during the collection and transformation of 67.2 t of blue agave leaves collected manually in the San Vicente community and transformed into silage*

Description	Unit Price (MXN)**	Total price (MXN)
Crusher machine rental	-	3 000
1 500 raffia sacks	9.25	13 875
Gasoline, electric light	-	500
13.44 sacks of urea, each one of 50 kg	350	4 704
Labor for collecting leaves	-	21 400
Labor for the silage	-	1 000
Total cost of 67 200 kg silage	-	44 479
Cost of kilograms of silage		1.51

Note: *1 kg of blue agave leaves produces approximately 1 kg of silage. Agave leaves were manually mechanically.

2. 4. Silage of agave leaves from San Vicente

Agave leaves from San Vicente were crushed in a warehouse in Salamanca, Guanajuato, México, using a rented machine handled by two people. Urea and plastic bags for packaging were purchased, and the total cost of the silage was calculated (table 2). If the 67.2 t of ensiled product were marketed at 2 MXN/kg, an income of 134 400 MXN would be obtained. The production cost of ensiling 67 200 kg was 44 479 MXN, i.e., 1.51 MXN/kg silage. The last data suggest that a net profit of 0.49 MXN/kg could be obtained if the silage were marketed at 2 MXN/kg.

2. 5. Benefit-cost analysis

Knowing the costs and income and considering that, on average, one hectare of agave produces 60 to 100 t of leaves (INIFAP, 2019; Panorama Agrario, 2016), the benefit-cost ratio (BCR) can be calculated. In La Grulla, 6.3% of a hectare was ensiled, obtaining a BCR of 1.18, implying that the agave producer earned 0.18 times the amount invested. On the other hand, in San Vicente, 84.0 % of a hectare was ensiled, resulting in a BCR of 3.02; that is, an income two times the amount invested (table 3).

TABLE 3

The benefit-cost ratio obtained for the silage of agave leaves in La Grulla and San Vicente

Community	Total cost (MXN)	Total income (MXN)	Benefit-cost ratio
La Grulla	8 450.00[a]	10 000	1.18
San Vicente	44 479.00[b]	134 400	3.02

Note: [a] = total cost for ensiling 5 000 kg of agave leave, [b] = total cost for ensiling 67 200 kg of agave leaves. The benefit-cost ratio in each community was calculated by dividing the total cost of the CTEAL process by the total income.

2. 6. *Agave* spp. leaves production in the state of Guanajuato

In the state of Guanajuato 20 778 ha of *Agave* spp. were harvested between 2017 and 2021. San Felipe, Romita, and Pénjamo had the highest harvested areas, with 4 750, 4 451, and 2 962 ha, respectively (table A1). Besides, Guanajuato produced 1488753.72 t of *Agave* spp. between 2017 and 2021. Romita, San Felipe, and Pénjamo municipalities had the highest production with 408133.30, 233369.25, and 213439.93 t, respectively (figure 2, table A2).

In the platforms of the *Consejo Regulador del Tequila* (CRT) and the *Servicio de Información Agroalimentaria y Pesquera* (SIAP), the statistic about agave is represented in terms of tons of agave, which in practical terms are the tons of core marketed. Considering that the weight of the leaves is nearly equal to the cores (Iñiguez-Covarrubias *et al*., 2001; Pérez-Zavala *et al*., 2020), it was estimated that Guanajuato produced approximately 1 488 753 t of *Agave* spp. leaves between 2017 and 2021 (table A2) (CRT, 2023; SIAP, 2023).

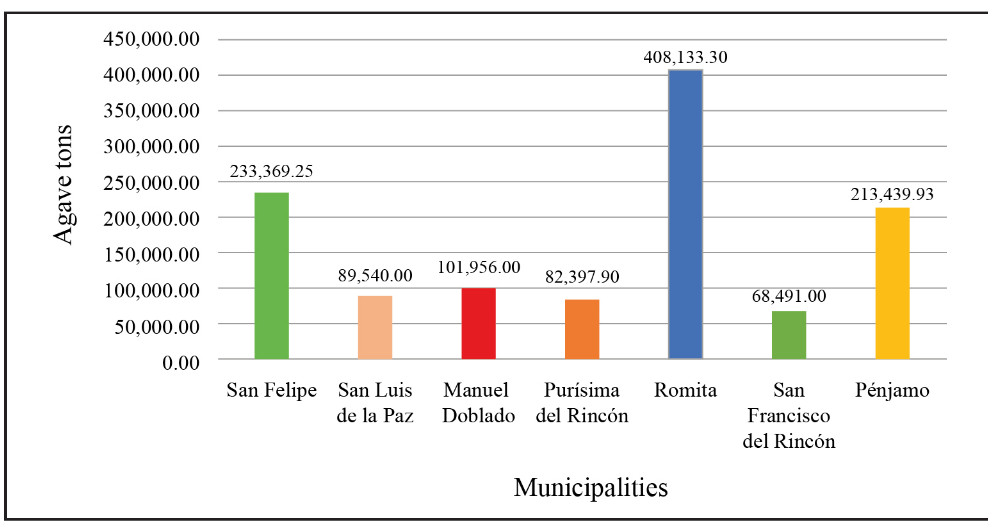

FIGURE 2

Municipalities of Guanajuato, Mexico with the highest production of tons of agave[a]

Note: [a] = agave production was calculated from 2017 to 2021. It is estimated that the weight of the agave leaves is similar to that of the cores (Iñiguez-Covarrubias *et al*., 2001). Data were obtained from SIAP (2023).

3. Discussion

Since agave leaves are generally discarded, there is little information related to their transformation and application (Escoto-García *et al*., 2006; Corbin *et al*., 2015; Davis *et al*., 2015; Stewart *et al*., 2015; Arreola-Vargas *et al*., 2016; López-Romero *et al*., 2018; Chávez-Romero *et al*., 2018). Here, we aimed to collect, transport, and ensile agave leaves (CTEAL) in two Guanajuato communities belonging to the municipalities of San Francisco del Rincón and Irapuato, where agave production has either increased or remained stable in recent years (tables A2). In addition, they were communities where the agave owners decided to participate in the study to know whether the silage process was an alternative to generate extra income.

La Grulla's total cost from collection to silage was slightly higher than in San Vicente. The price for collecting the leaves in La Grulla was 0.38 MXN/kg, whereas in San Vicente was 0.32 MXN. In contrast, the total cost to produce 1 kg of silage was 1.69 and 1.51 MXN in La Grulla and San Vicente, respectively. Even though the CTEAL in San Vicente is more complex than in La Grulla because it involves transportation and ensiling to a different city, the benefit-cost ratio is higher (3.02 vs 1.18). As the silage process used in both communities was the same, the difference could be partly attributed to the way the leaves were collected, suggesting that the mechanical collection of agave leaves (San Vicente) is preferable to the manual collection (La Grulla) because the number of leaves collected is higher. Furthermore, the automated collection improves worker safety because they are not in direct contact with the agave leaves' thorns, which can cause injuries, or with the sap, which can cause irritative dermatitis, as is the case with some types of agaves like *A*. americana (De la Cueva *et al*., 2005). It should be noted that although the benefit-cost ratios are not so high, the CTEAL to produce agave leaf silage might be a workable commercial alternative with the potential to be improved, or for self-consumption by mixing with cattle commercial food (Reyes-Castro *et al*., 2022) helping to reduce the cost invested in the purchase of food, mainly in marginal regions or with severe drought conditions.

Unfortunately, the costs associated with collecting, transporting, and ensiling the agave leaves could not be benchmarked with other works as we did not find similar reports in the literature. Most agave silage research to date has centered on explaining the silage process, its composition, and the impact on animal nutrition (Pinos-Rodríguez *et al*., 2006, 2009; Nasri y Salem, 2012; Álvarez-Fuentes *et al*., 2015; Reyes-Castro *et al*., 2022). On the other hand, comparing data with those generated with other by-products can be challenging due to differences in the type of material, silage methods, and process inputs, which can vary in price depending on the country, state, or region (Villalobos-Villalobos *et al*., 2015). For example, fodder oats cost about 1.27 MXN in a trench and 1.48 MXN in a heap; corn silage ca. 0.97 MXN in a trench and 1.48 MXN in a pile, and sorghum 0.38 MXN per heap (Villalobos Villalobos *et al*., 2015). To ensile the orange pulp, it costs 0.91 MXN/kg of fresh silage and 5.36 MXN/kg of dry-based silage (Morales González *et al*., 2009). Although the cost of agave leaf silage cannot be directly compared to other types of silage, we demonstrated that the cost per kilogram (1.69, 1.51 MXN) is comparable to fodder oats and heap corn silage (Villalobos Villalobos *et al*., 2015).

Finally, an analysis of the information published by the CRT and SIAP during 2017-2021 showed that more than one million tons of *Agave* spp. leaves were generated in the state of Guanajuato (table A2), where municipalities such as Romita, Pénjamo, Manuel Doblado, Purísima del Rincón, Abasolo, Cuerámaro and Huanímaro alone generated 63.25% of total production (SIAP, 2023). This datum showed tons of agave leaves that could be ensiled for self-consumption or to create extra income for agave producers.

Prospective

One of the problems we have as humans is the world's pollution, and it is essential to exist in harmony with nature to support the present and future generations. When agave leaves are forgotten in the field and burned, they cause environmental pollution and affect the soil microbiota. In this regard, we should consider whether collecting agave leaves and not burning them, but transforming them into silage that contributes to a cleaner environment and generates income or serves as feed for livestock for self-consumption. In a strict sense, this process falls within the bioeconomy since a biological source (agave leaves) is used to generate a service (silage, livestock feed) sustainably (Aguilar *et al*., 2019). Given the benefits of this sustainable process, why not engage in a process such as CTEAL? Even though the benefit-cost ratio found in this study is not very high, it is believed that this ratio can increase once the CTEAL process is optimized for different Agave species, taking into account the age of the plant, soil fertility, automated collection, or modifying the way of ensiling (e.g., using large containers instead of plastic bags to carry out the fermentation process). Also, the silage can be mixed with other organic materials (e.g., nopal) to increase the nutritional value and do a benchmarked analysis with silages obtained from other organic products (e.g., orange pulp, corn stover, sorghum, nopal). In other words, the CTEAL process can help to develop and visualize new business models. As this work was limited to two communities, it will be essential to perform a similar study in other communities, as each one has different conditions, and the benefit-cost ratio may change. As indicated above, it will be interesting to make a benchmarked study between the CTEAL using different agaves; it is well known that Mexico possesses around 150 agave species. Another critical point to be considered is whether the agave owners are interested in the CTEAL. To elucidate it, conducting surveys along Guanajuato (or Mexico) will be necessary to gauge their interest and develop a sustainable business plan. Finally, leaves that do not enter the silage process can be macerated and used *in situ* to be incorporated into the soil organic material, as is the case with agave tequila bagasse (Acosta Sotelo *et al*., 2023).

Conclusions

Data show that collecting, transporting, and ensiling agave leaves can generate income that may benefit agave growers, which supports our hypothesis. It is important to note that we used agave leaves collected after the *jima* from a single agave species, generating a specific benefit-cost ratio. However, future works should consider other variables, such as fertigation (Ríos-Ramírez *et al*., 2021), soil fertility, agave species (Barrientos Rivera *et al*., 2019), plant age, climatic conditions, the technology used in agave cultivation, and the core to leave ratio depending on the agave species. Besides, a multifactorial analysis will be required, including an analysis of the supply-demand at different times of the year, regionalization, market, and product quality. All those factors can modify the benefit-cost ratio. Nonetheless, even though the benefit-cost ratio was low under the conditions used in this study (i.e., 3.04 X, 1.18X), it has the potential for improvement and could be used to motivate agave farmers to apply the CTEAL process.

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Annex

TABLE A1

Harvested area (ha) of agave in different municipalities of the State of Guanajuato[a]

Municipality	2017	2018	2019	2020	2021	Total
San Miguel de Allende	0	0	0	0	2	2
San Felipe	1 851.00	1 600	575	225	300	4 551
San Luis de la Paz	0	0	0	650	800	1 450
Manuel Doblado[b]	150	120	200	300	350	1 120
Guanajuato	0	2	6	10	30	48
León	30		21	21	20	92
Purísima del Rincón	76	110	180	250	301	917
Romita	700	800	1 120.00	1 030.00	1100	4 750
San Francisco del Rincón	0	80	200	200	300	780
Silao de La Victoria	60	80	120	60	120	440
Apaseo El Alto	2	3	8	6	6	25
Apaseo El Grande	9	10	13	9	9	50
Comonfort	55	69	33	26	26	209
Jerécuaro	95	142	17		5	259
Juventino Rosas	10	12	6	5	5	38
Tarimoro	6	8	6	4	5	29
Abasolo	228	241	100	90	95	754
Acámbaro	187	92		11	11	301
Cortazar	6	0				6
Cuerámaro	111	115	60	80	70	436
Huanímaro	39	160	180	150	182	711
Irapuato	150.5	41.3	59.5	52	49	352.3
Pénjamo	1 185.00	915	172	185	505	2 962
Pueblo Nuevo	45	41	41	39	37	203
Salamanca	20.5	0	10	10	10	50.5
Salvatierra	13	0	0	0	0	13
Tarandacuao	18	0	0	4	4	26
Valle de Santiago	20	10	63.4	54	52	199.4
Villagrán	2	0	0	0	2	4
TOTAL	5 069.00	4 651.30	3 190.90	3 471.00	4 396.00	20 778.20

Note: [a] = data was obtained from the SIAP (2023). [b] = are indicated the municipalities with the denomination of origin of tequila according to CRT (2023).

TABLE A2

Production of tons of core of de Agave spp. in different municipalities of the state of Guanajuato[a]

Municipality	2017	2018	2019	2020	2021	Total
San Miguel de Allende	0	0	0	0	108	108
San Felipe	64 785.00	104 000.00	29 008.75	14 575.50	21 000.00	23 3369.25
San Luis de la Paz	0	0	0	41 548.00	47 992.00	89 540.00
Manuel Doblado[b]	13 650.00	10 950.00	18 110.00	27 900.00	31 346.00	101 956.00
Guanajuato	0	174	489.06	824	2 356.20	3 843.26
León	2 250.00	0	1 365.00	1 470.00	1 424.60	6 509.60
Purísima del Rincón	6 916.00	9 988.00	15 969.60	23 000.00	26 524.30	82 397.90
Romita	59 500.00	71 600.00	96 891.20	90 712.10	89 430.00	408 133.30
San Francisco del Rincón	0	7 280.00	17210.00	18 300.00	25 701.00	68 491.00
Silao de La Victoria	5 040.00	6 920.00	10 454.40	5 238.00	9 756.00	37 408.40
Apaseo El Alto	186	183.6	497.2	369	353.22	1 589.02
Apaseo El Grande	549	630	807.95	576	542.97	3 105.92
Comonfort	2 255.20	4 399.75	1 434.96	1 106.40	1 070.96	10 267.27
Jerécuaro	6 200.00	6 349.96	1 229.10	0	290	14 069.06
Juventino Rosas	549	714	379.98	313.25	307.2	2 263.43
Tarimoro	420	534.4	398.1	259.2	314.55	1 926.25
Abasolo	17 746.00	17 403.00	6 020.00	6 750.00	6 935.00	54 854.00
Acámbaro	13 145.50	4 540.20	0	870	741.26	19 296.96
Cortazar	420	0	0	0	0	420.00
Cuerámaro	7 853.75	8 186.00	4 630.80	5 000.00	4 893.00	30 563.55
Huanímaro	2 714.06	11 370.00	10 890.00	11 100.00	14 272.00	50 346.06
Irapuato	9 097.34	1 412.02	4 173.93	4 877.08	4 548.18	24 108.55
Pénjamo	101 464.03	60 480.00	11 299.90	11 924.40	28 271.60	213 439.93
Pueblo Nuevo	2 999.60	1 471.90	3 327.60	3 535.30	3 358.50	14 692.90
Salamanca	1 409.25	0	650	910	921	3 890.25
Salvatierra	975	0	0	0	0	975.00
Tarandacuao	1 116.00	0	0	288	292.28	1 696.28
Valle de Santiago	1 820.00	900	1 900.10	2 140.02	2 396.68	9 156.80
Villagrán	144	0	0	0	191.78	335.78
TOTAL	323 204.73	329 486.83	237 137.63	273 586.25	325 338.28	1 488 753.72

Nota: [a] = It is estimated that the weight of the leaves is similar to the weight of pineapples (Iñiguez-Covarrubias *et al.*, 2001). Data was obtained from SIAP (2023). [b] = are indicated the municipalities with the denomination of origin of tequila according to the CRT (2023).